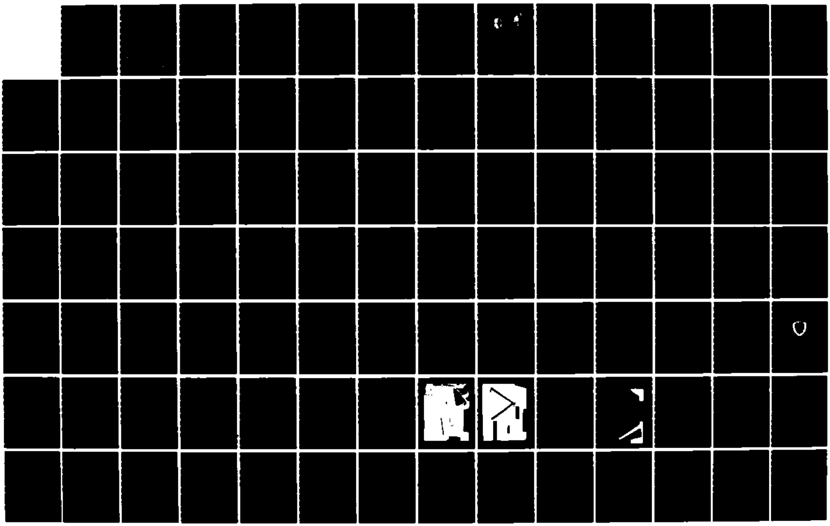
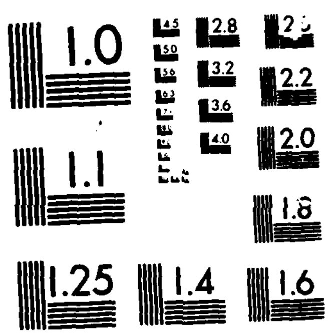
AD-A165 897 VHF-FM COMMUNICATIONS ANTENNAS FOR PROJECT SINCGARS 1/2
(UH-1 TAIL WHIP ANTENNA EVALUATION)(U) ARMY AVIATION
SYSTEMS COMMAND ST LOUIS MO J CARALYUS ET AL. FEB 86
UNCLASSIFIED AVSCOM-TR-85-E-2 F/G 17/2.1 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A165 897

AVSCOM

Technical Report-85-E-2

VHF-FM COMMUNICATIONS ANTENNAS FOR PROJECT SINCGARS (UH-1 TAIL WHIP ANTENNA EVALUATION)

JOSEPH CARALYUS
JOSEPH MILLER
FRANK CANSLER

US ARMY AVIONICS R&D ACTIVITY

FEBRUARY 1986

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A full-scale study was conducted by the Naval Air Development Center, Warminster, PA (NADC), for the C3 Division of the U.S. Army Avionics Research and Development Activity (AVRADA), Fort Monmouth, NJ, to test and evaluate production prototype antenna systems that essentially met the requirement for SINCGARS operation when installed on an Army UH-1 helicopter. The results of these tests determined a suitable tail whip antenna to be used on the UH-1 to satisfy the SINCGARS requirement between 30 and 88 MHz.

This technical report describes the results of tests conducted on antennas manufactured by three major Airborne Antenna manufacturers, each of whom attempted to provide an antenna system that would directly replace the standard Army CU-942B antenna, and satisfy the more stringent requirements of project SINCGARS.

The information in this report provides, in part, the technical data for the production data package of an adequate VHF-FM Communications antenna for the UH-1 aircraft.

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1. OBJECTIVE

The object of this test was to conduct swept frequency measurements of candidate replacement antennas and couplers for the US Army UH-1B Helicopter. The measurements were made with the test items mounted on a full-scale helicopter. The frequency band was 30-88 MHz.

2. TEST ITEMS

The test items in these measurements were the following bent whip antennas and straight whip antenna couplers:

Bent Whip Antennas:

FM 10-30-1, SN 582, Army Standard

AS-3595, SN 011, Quad Pod

AO-1956, SN 001, AEL

FM 10-30-4, SN E010, Dayton Granger

Antenna Couplers with Straight Whip:

CU-942B, Army Standard

AV 11-401A, SN 0004, Avant

AV 11-1011, SN 0001, Avant

FM 10-22-6, SN 0002, Dayton Granger

AO-1955, SN 0001, AEL

3. TEST FACILITY

The test measurements were conducted at the Naval Air Development Center Antenna Test Facility located in Warminster, PA. A UH-1B Army Helicopter was transported to the test facility and placed on a 20 by 24-foot cement pad located 500 feet from Building 115. Figure 1 shows how the test range was set up for these measurements.

4. TEST CONFIGURATION

The bent whip antennas and the couplers with their associated whip antennas were mounted on the helicopter in their normal flight location (Fig. 2). Swept frequency measurements were made from the front, right side, and rear of the helicopter.

The test measurement equipment was located in the equipment van and configured as shown in Figure 3. The swept frequency signals were transmitted from the test items and received by an APN-1596 Log Periodic Antenna. An APN-995B Log Periodic was used as a reference antenna.

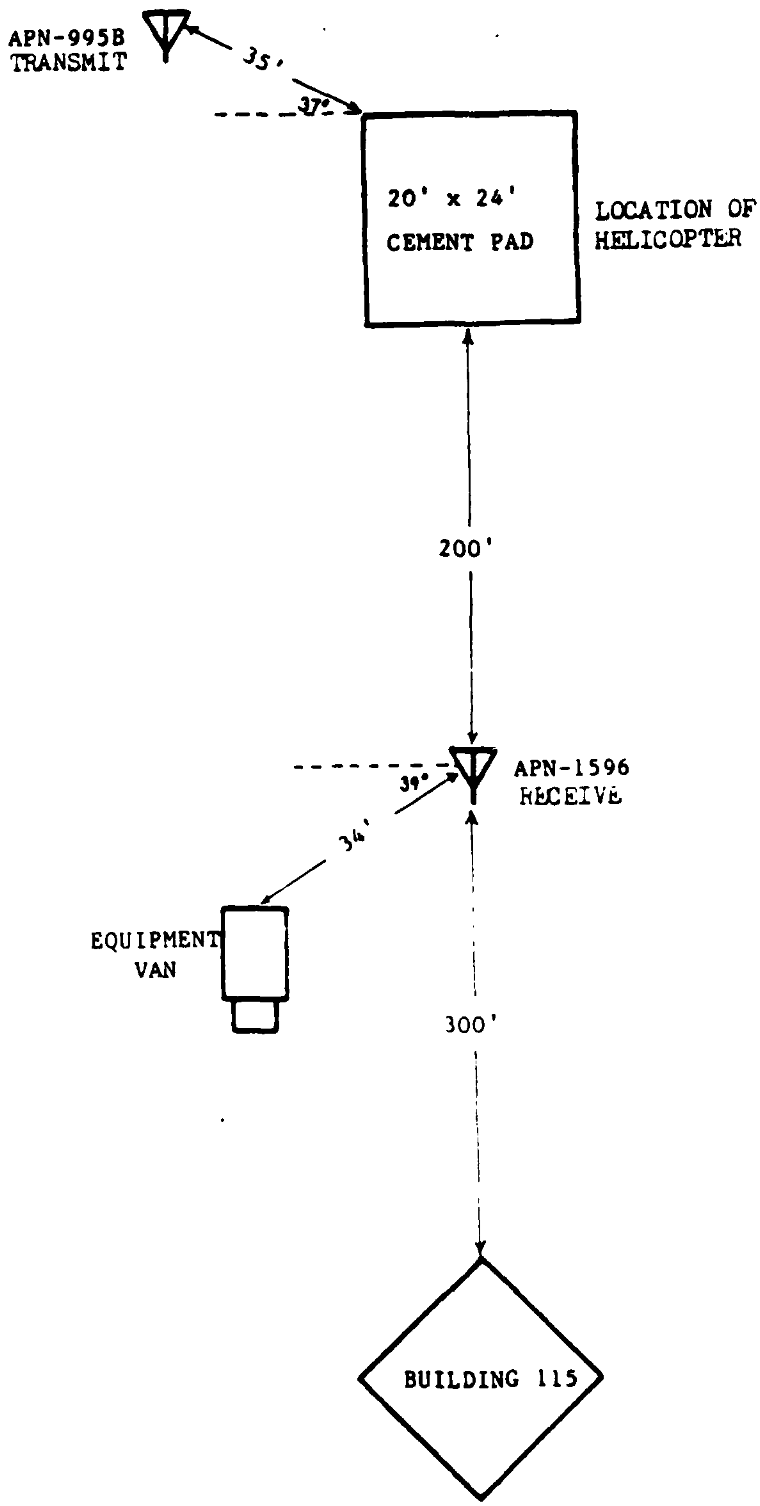


Figure 1. Test Range Setup.

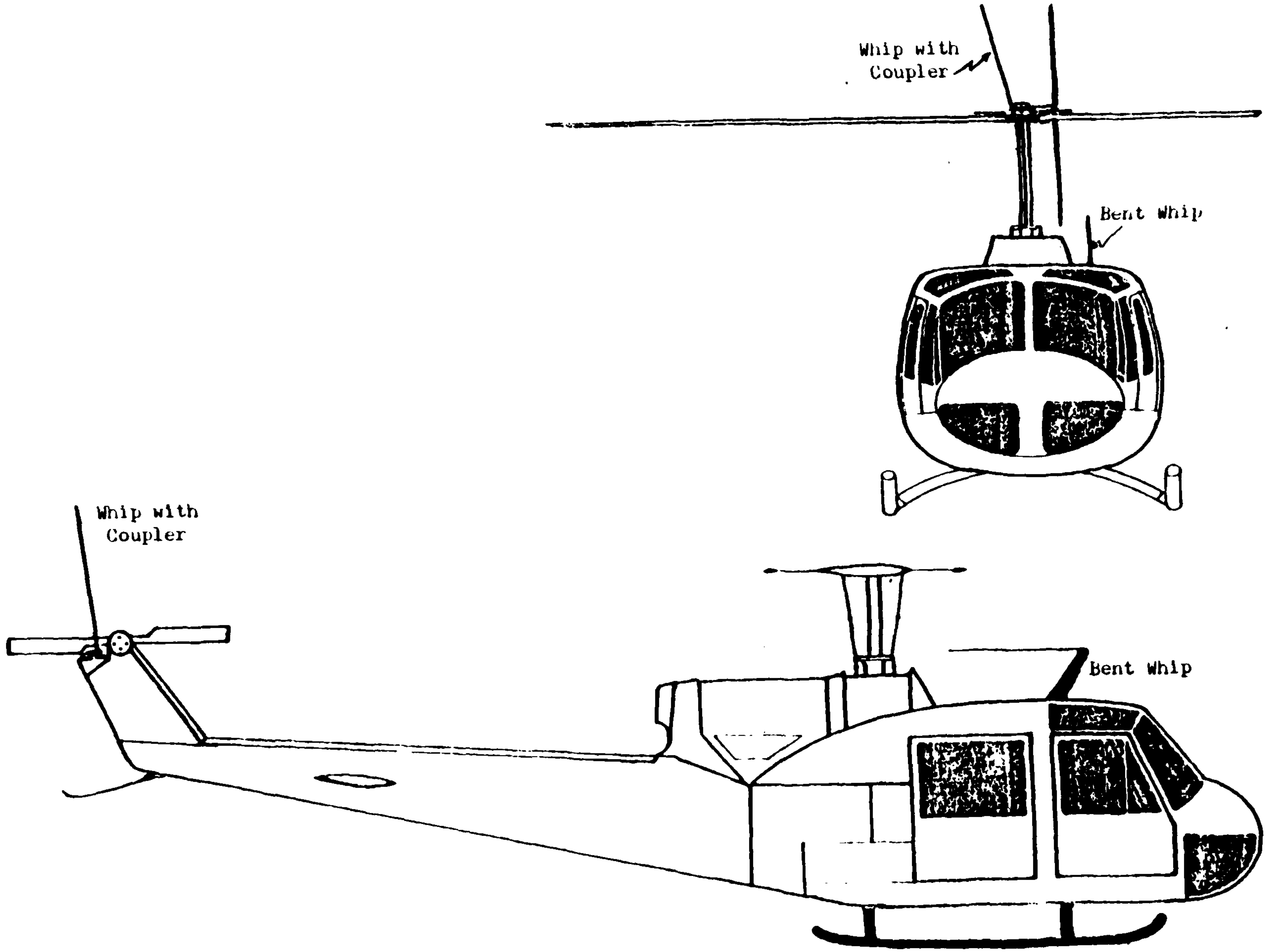


Figure 2. Antenna Locations on UH-1B Helicopter

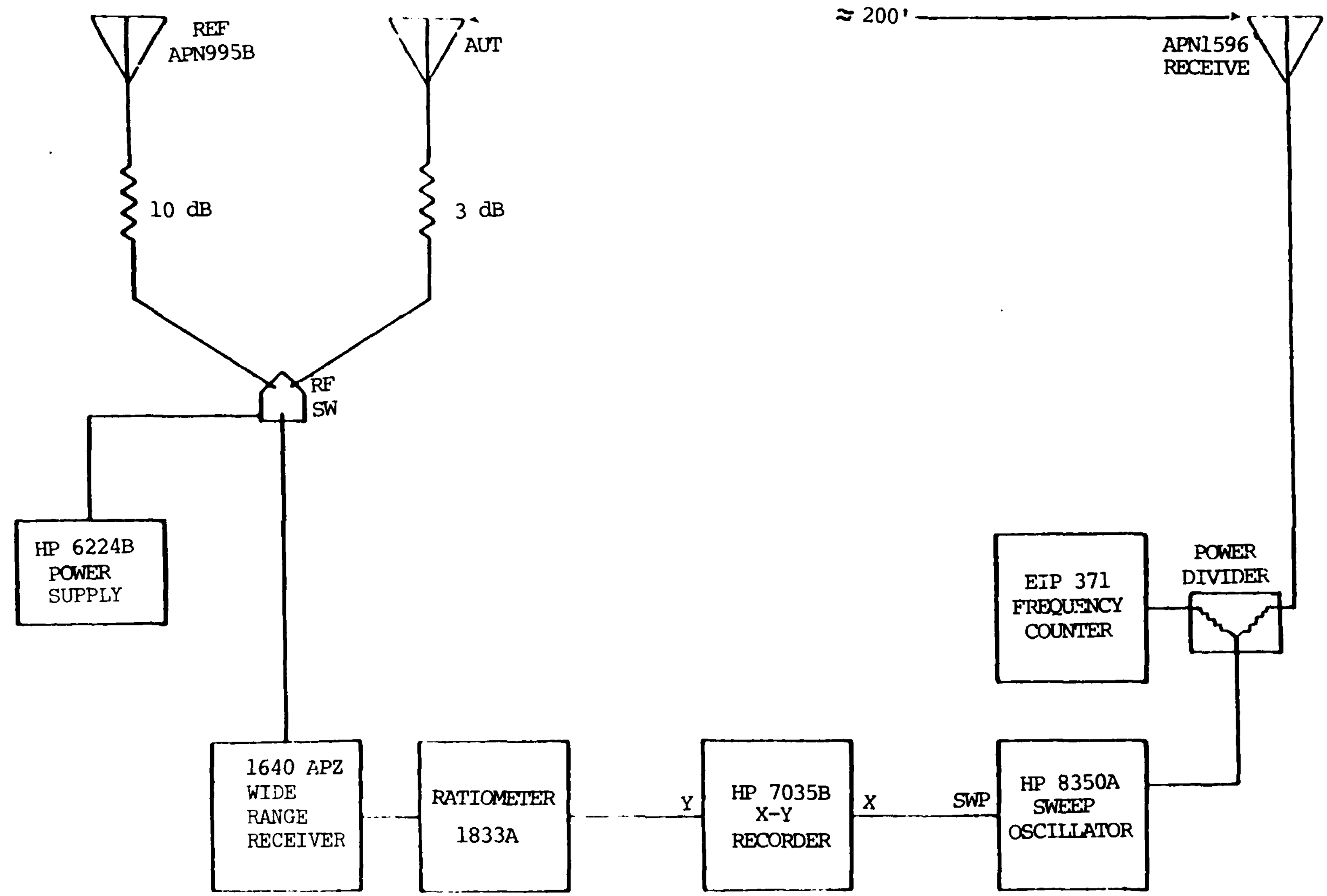


Figure 3. Test Measurement Equipment Configuration

5. TEST PROCEDURE

For each measurement, the test item was mounted on the helicopter and connected to the sweep oscillator through a 3 dB pad and an RF switch. The other port of the switch was connected to the reference antenna through a 10-dB pad to reduce its transmit level.

The reference antenna transmit level was monitored prior to the start of each sweep to assure that the oscillator output power did not vary from one sweep to the next.

The oscillator output was switched to the reference antenna whose output level was recorded over the frequency band. This was done by setting the sweep oscillator for a slow single cycle sweep (60 seconds) and then locking the receiver on the start frequency with the Automatic Frequency Control (AFC) prior to the start of the sweep. The output of the sweep oscillator was then switched to the first test item and its output recorded.

This procedure was repeated for all test items with the UH-1B in the three (3) test positions: front, side, and rear.

6. DATA PRESENTATION

The swept frequency data was reduced and plotted against the output of the reference antenna. This was accomplished by normalizing the reference antenna signal level and plotting the test item deviation from that level. Although the plotted levels are not absolute values, they are relative to each other and show the gain differences between the test items.

The AEL AO-1956 and the Army FM 10-30-1 Bent Whip Antennas were only plotted to 82 MHz. This is because the gain of these antennas decreased at the high end of the frequency band to a point that their transmit levels dropped below the level of an extraneous signal present at approximately 82.5 MHz. This caused the AFC of the receiver to lock on the extraneous signal and prevent further recording of the test item signal. This also occured on the Army CU-942B and AEL's AO-1955 when transmitting from the right side of the helicopter. The Army CU-942B and AEL AO-1955 also experienced extremely low signal levels at 30-31 MHz when transmitting from the rear and the side of the helicopter. Although it did not affect the other straight whip antennas, this could have been caused by the transmit antenna feed cable resonating at this frequency. The patterns were repeated several times for each antenna coupler with the same results. Further investigation into this area could not be undertaken at this time because of the time limit set by flight operations. The helicopter had to be flown out of the test area before NADC flight operations closed for the day (1700 hours).

The gain plots are presented in the Appendices as follows:

Appendix A - Front of Helicopter

Appendix B - Right Side of Helicopter

Appendix C - Rear of Helicopter

The swept frequency patterns were cataloged and are presented as recorded. A slight difference in the reference antenna pattern occurs between the data collected on December 5 and 7, 1984. The test was interrupted on December 6 due to rain and high winds. The reference and receive antenna masts were lowered at that time. The slight difference is most likely due to the antennas not being erected in the same exact position as on the first day of testing.

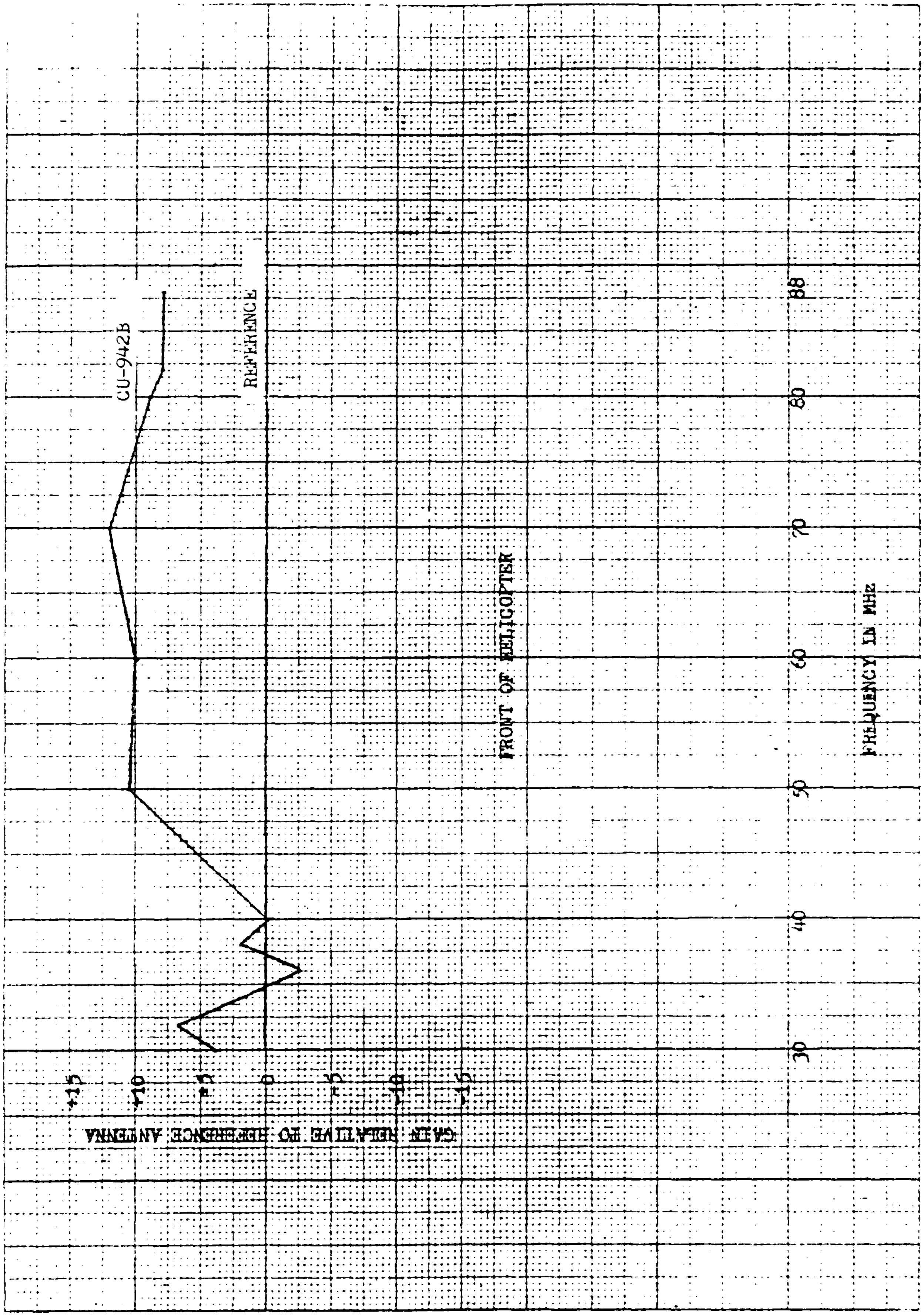
The swept frequency patterns are presented as follows:

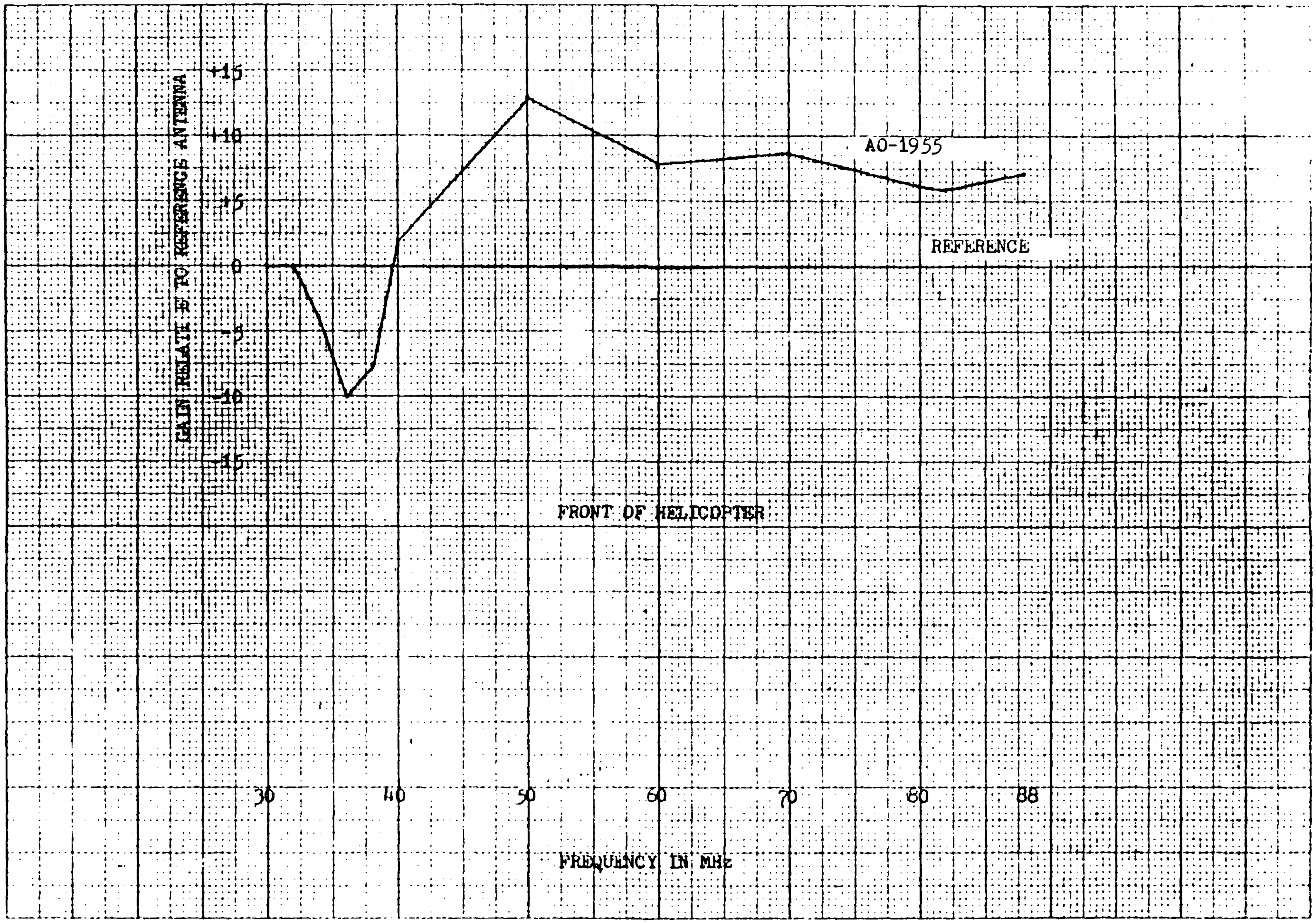
Appendix D - Front of Helicopter

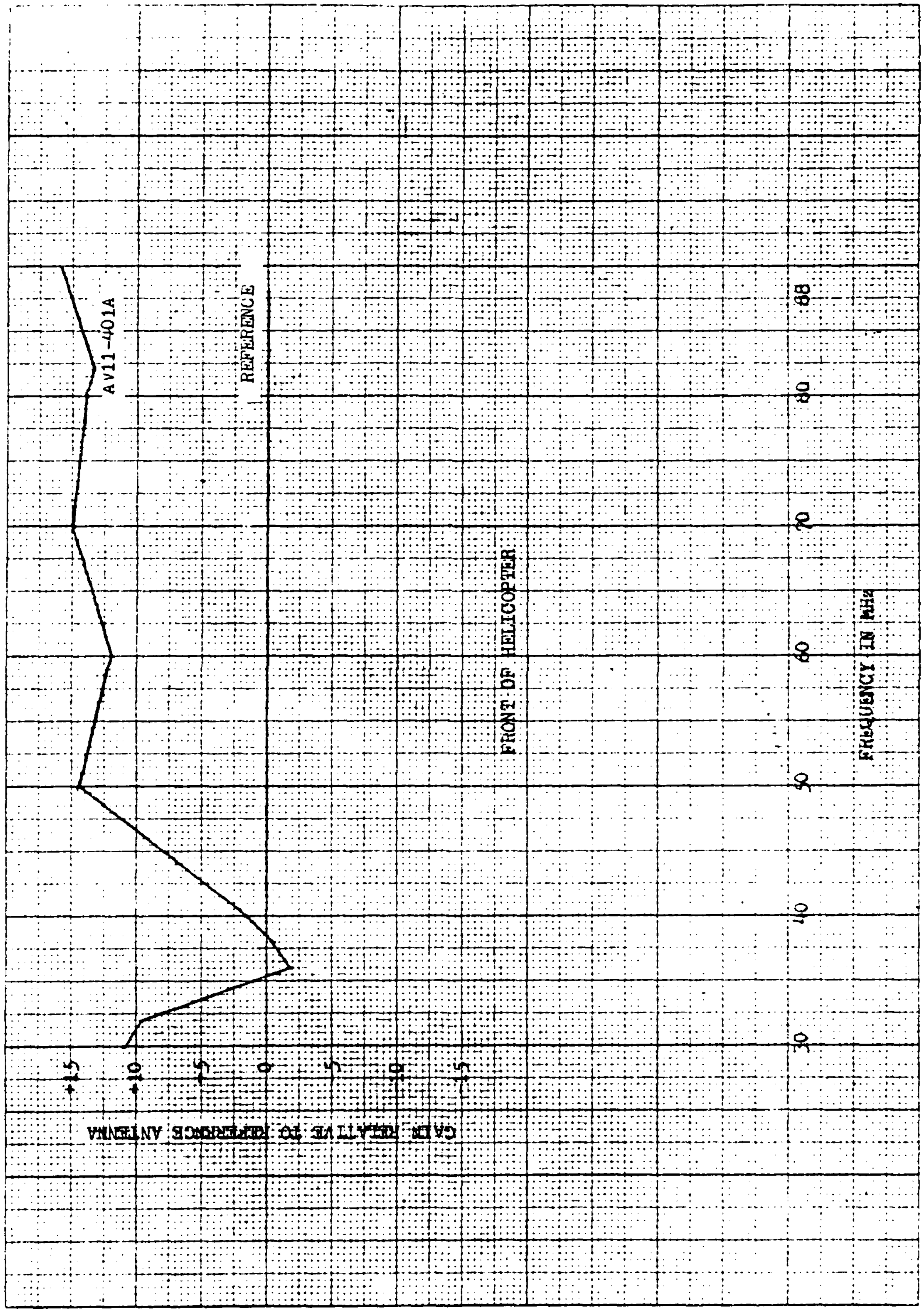
Appendix E - Right Side of Helicopter

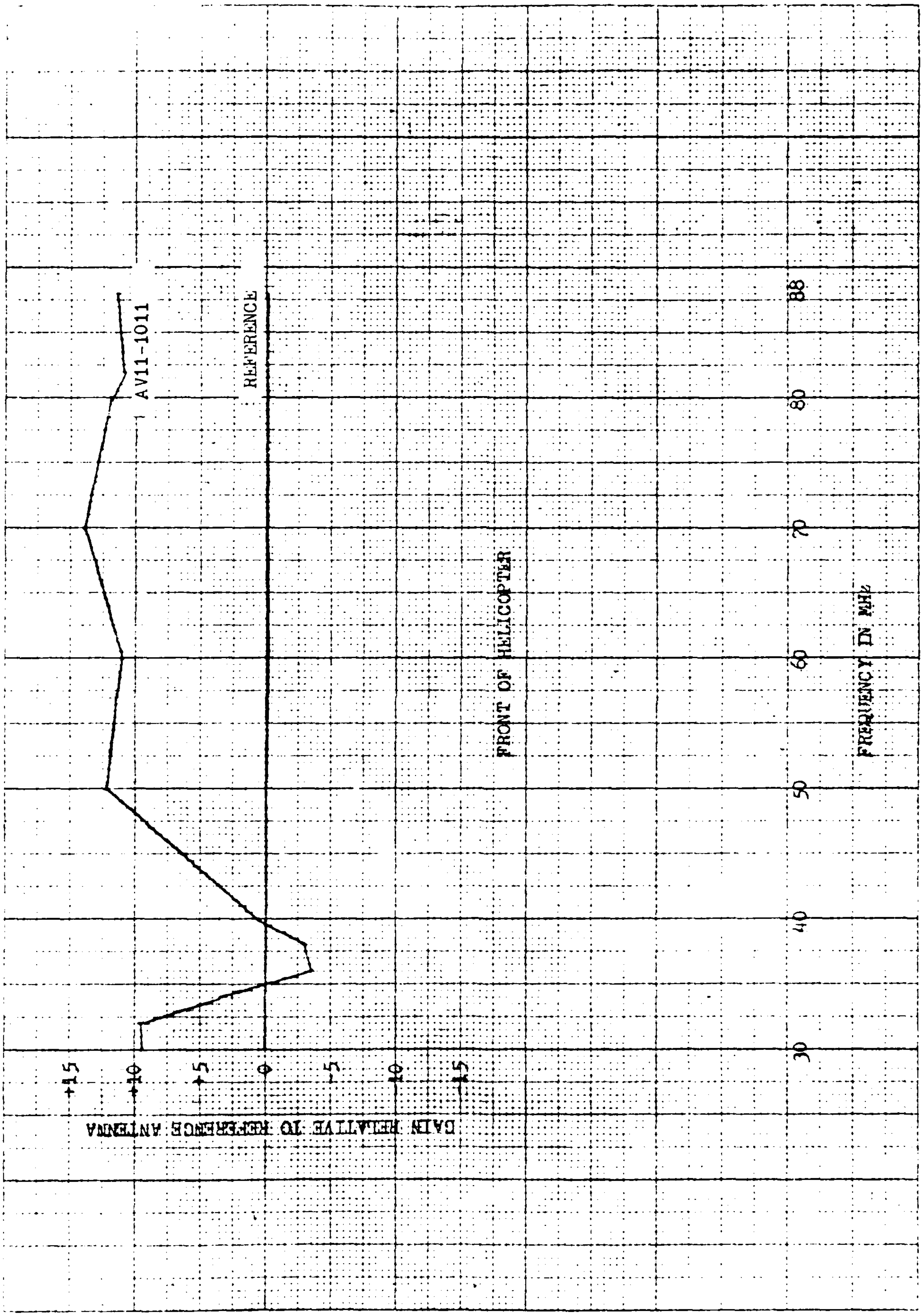
Appendix F - Rear of Helicopter

APPENDIX A. GAIN PLOTS FROM FRONT OF HELICOPTER

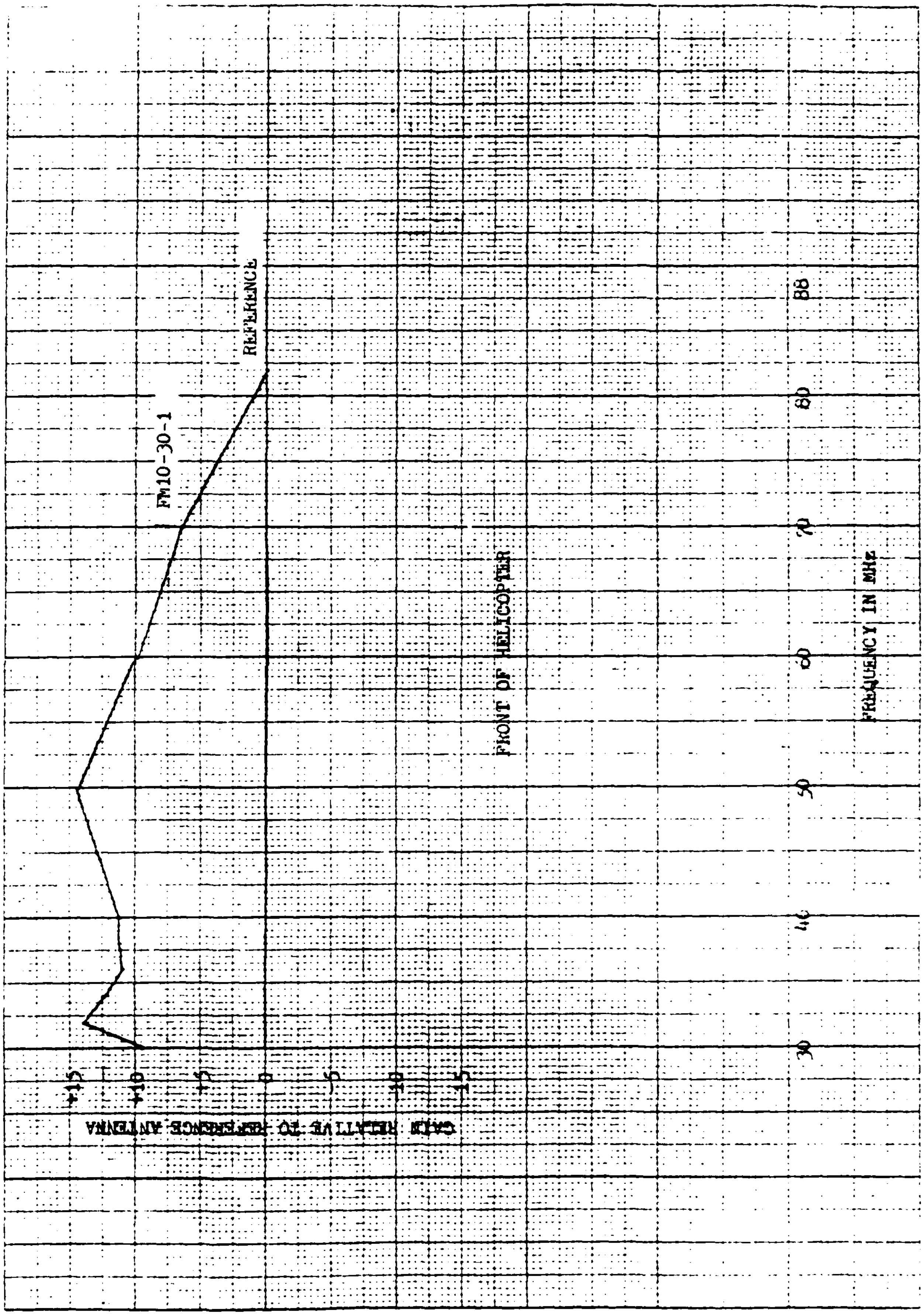

CU-942B
REFERENCE
FRONT OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88

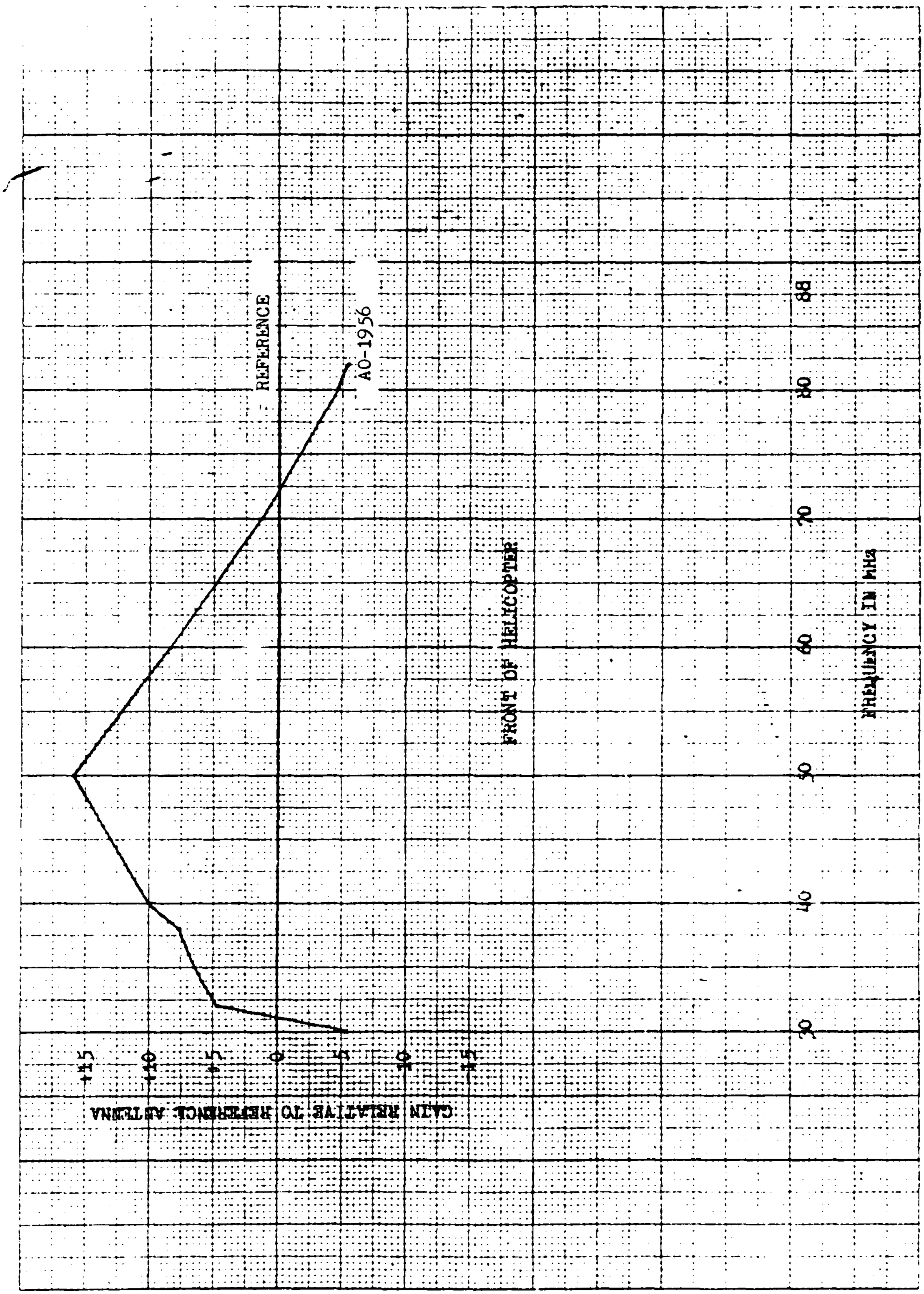

GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
A0-1955
REFERENCE
FRONT OF HELICOPTER
30
40
50
60
70
80
88
FREQUENCY IN MHz

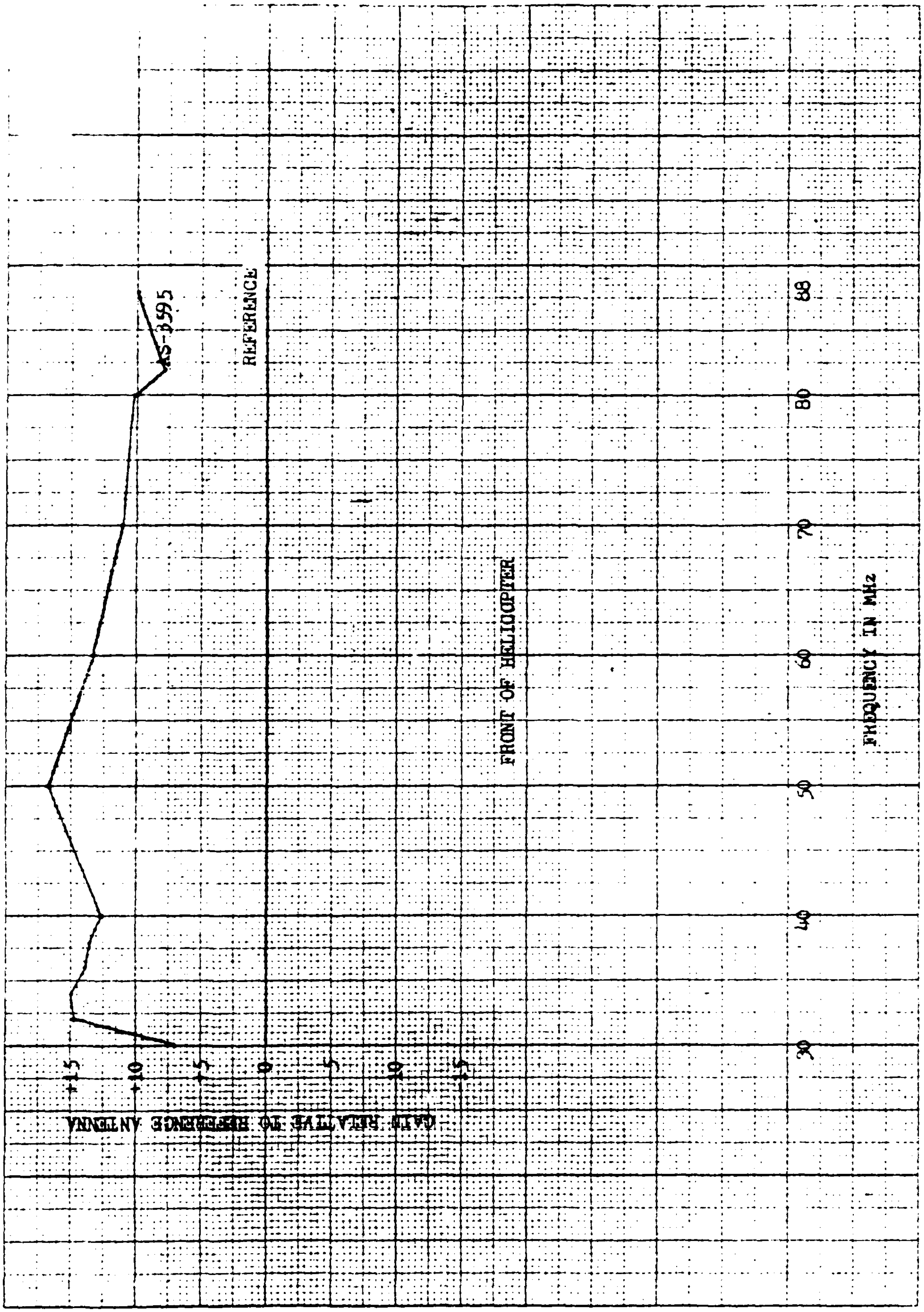

AV11-401A
REFERENCE
FRONT OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88



AV11-1011
REFERENCE
FRONT OF HELICOPTER
FREQUENCY IN MHz
30
40
50
60
70
80
88
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15

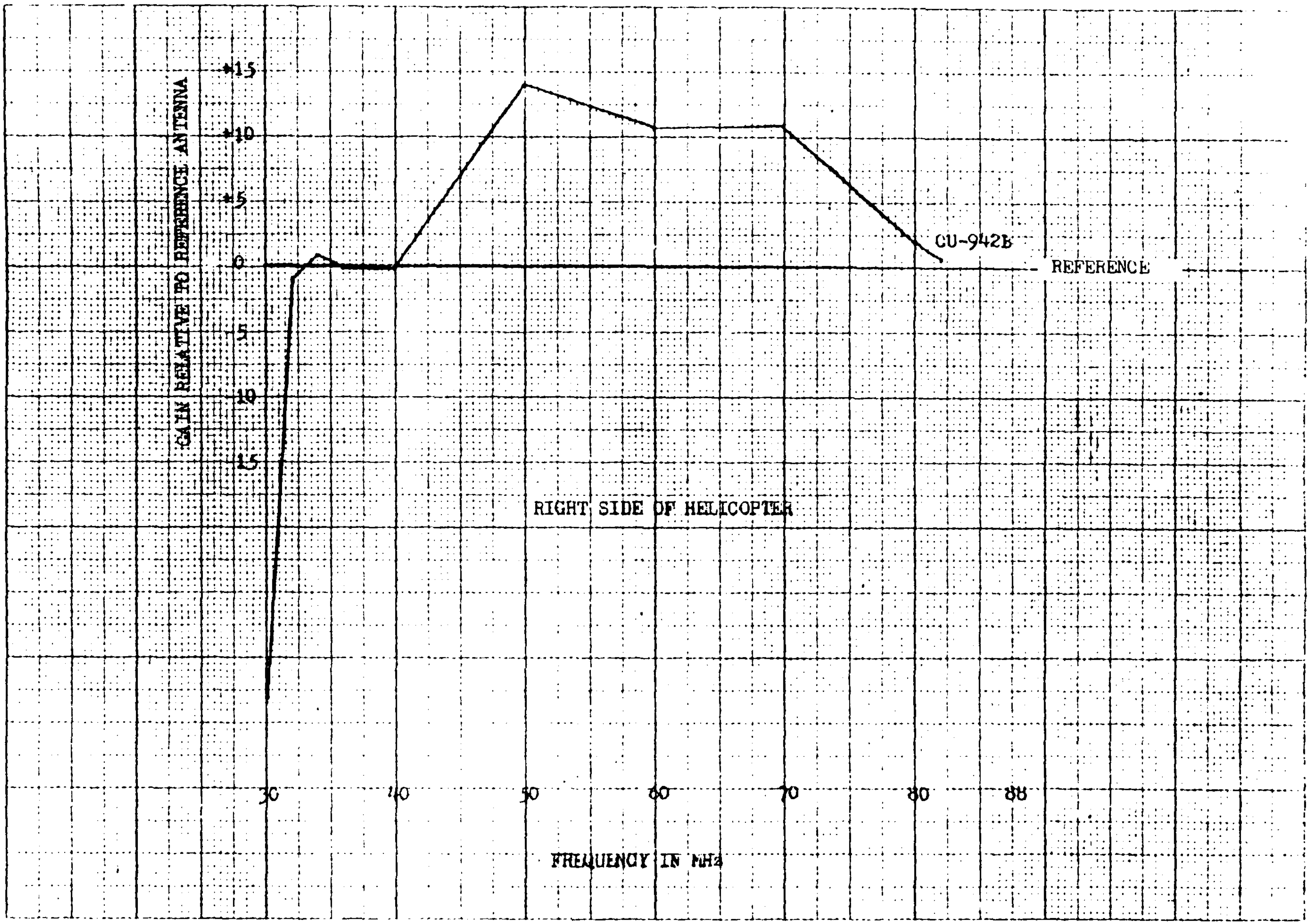

FM10-30-1
REFERENCE
FRONT OF HELICOPTER
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88
FREQUENCY IN MHz

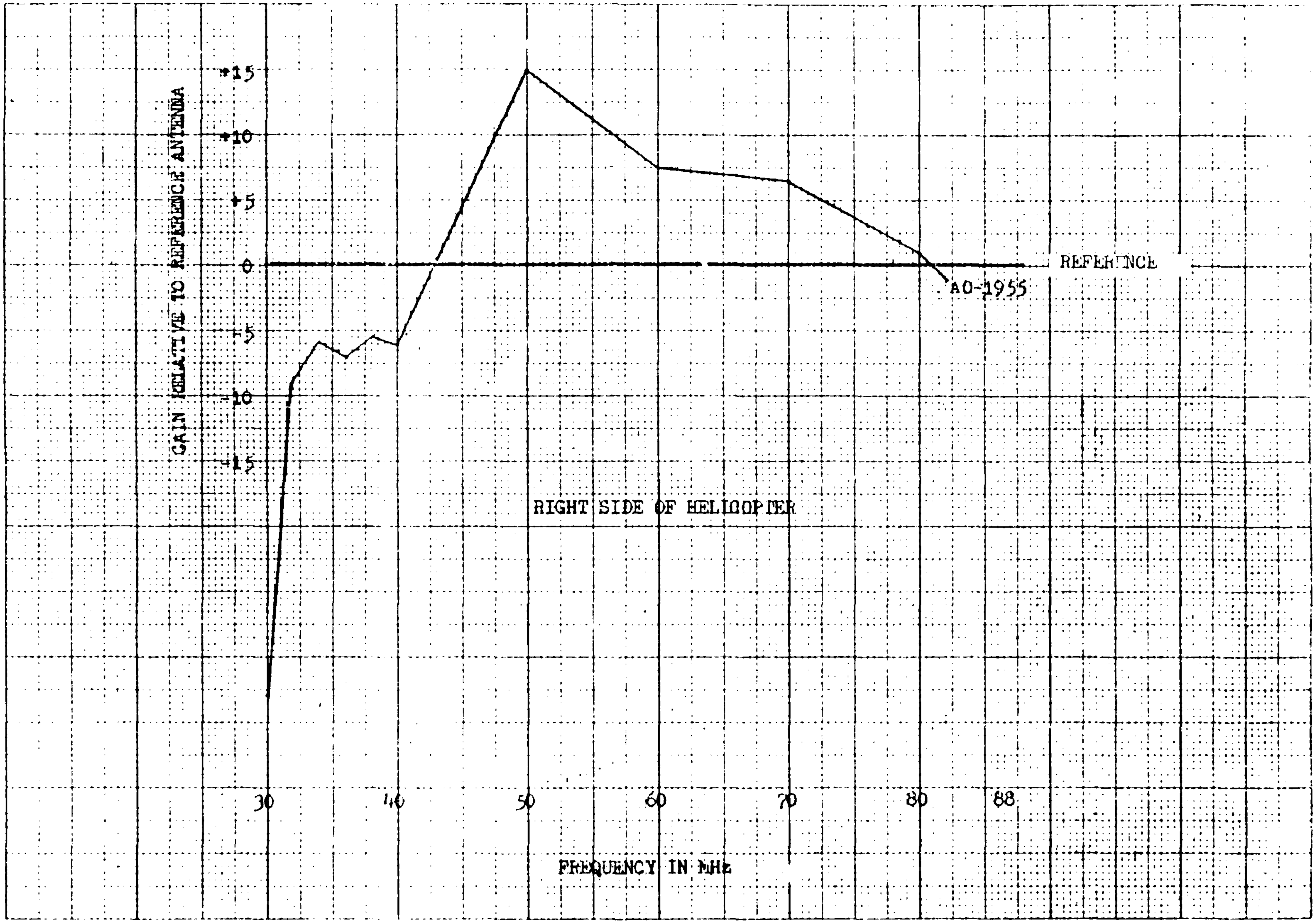

REFERENCE
AO-1956
FRONT OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
5
10
15
30
40
50
60
70
80
88

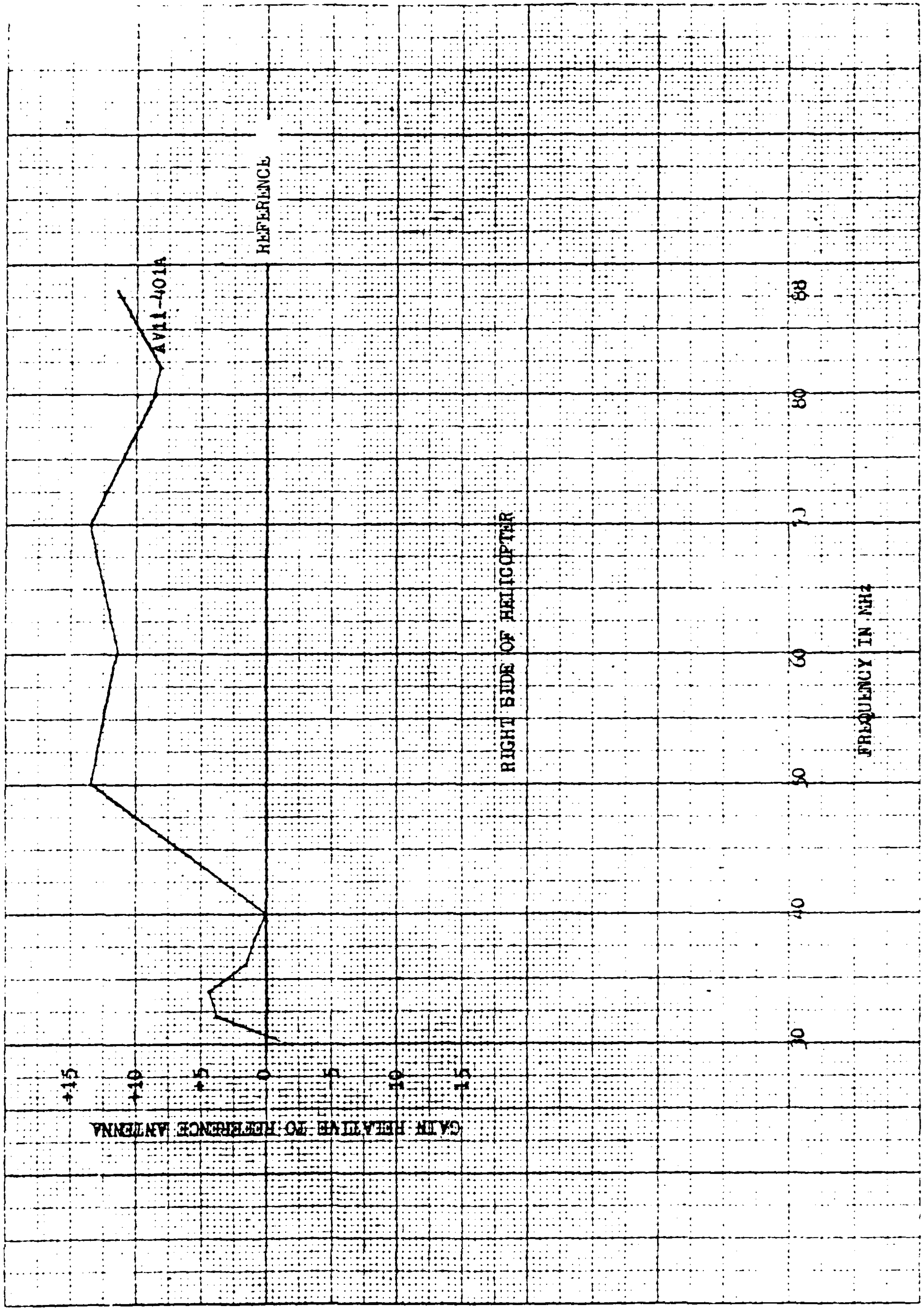


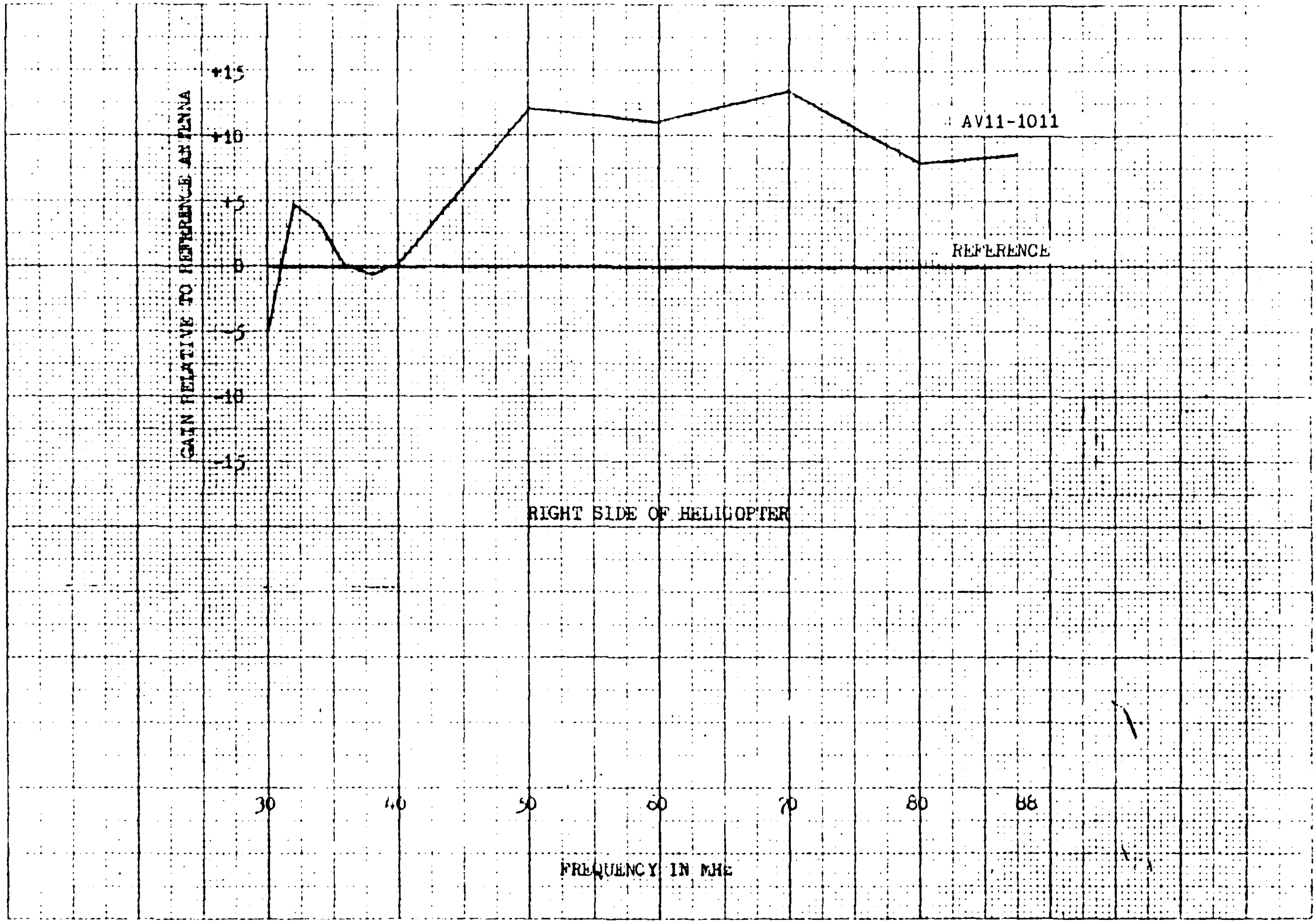
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88
FREQUENCY IN MHz
FRONT OF HELICOPTER
REFERENCE
AS-3595

APPENDIX B. GAIN PLOTS FROM SIDE OF HELICOPTER


GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
5
10
15
CU-942B
REFERENCE
RIGHT SIDE OF HELICOPTER
30
40
50
60
70
80
88
FREQUENCY IN MHz


GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
REFERENCE
AO-1955
RIGHT SIDE OF HELICOPTER
30
40
50
60
70
80
88
FREQUENCY IN MHz


REFERENCE
AVII-401A
RIGHT SIDE OF HELICOPTER
FREQUENCY IN MHZ
30
40
50
60
70
80
88
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
5
10
15


+15
+10
+5
0
-5
-10
-15
GAIN RELATIVE TO REFERENCE ANTENNA
AV11-1011
REFERENCE
RIGHT SIDE OF HELICOPTER
30
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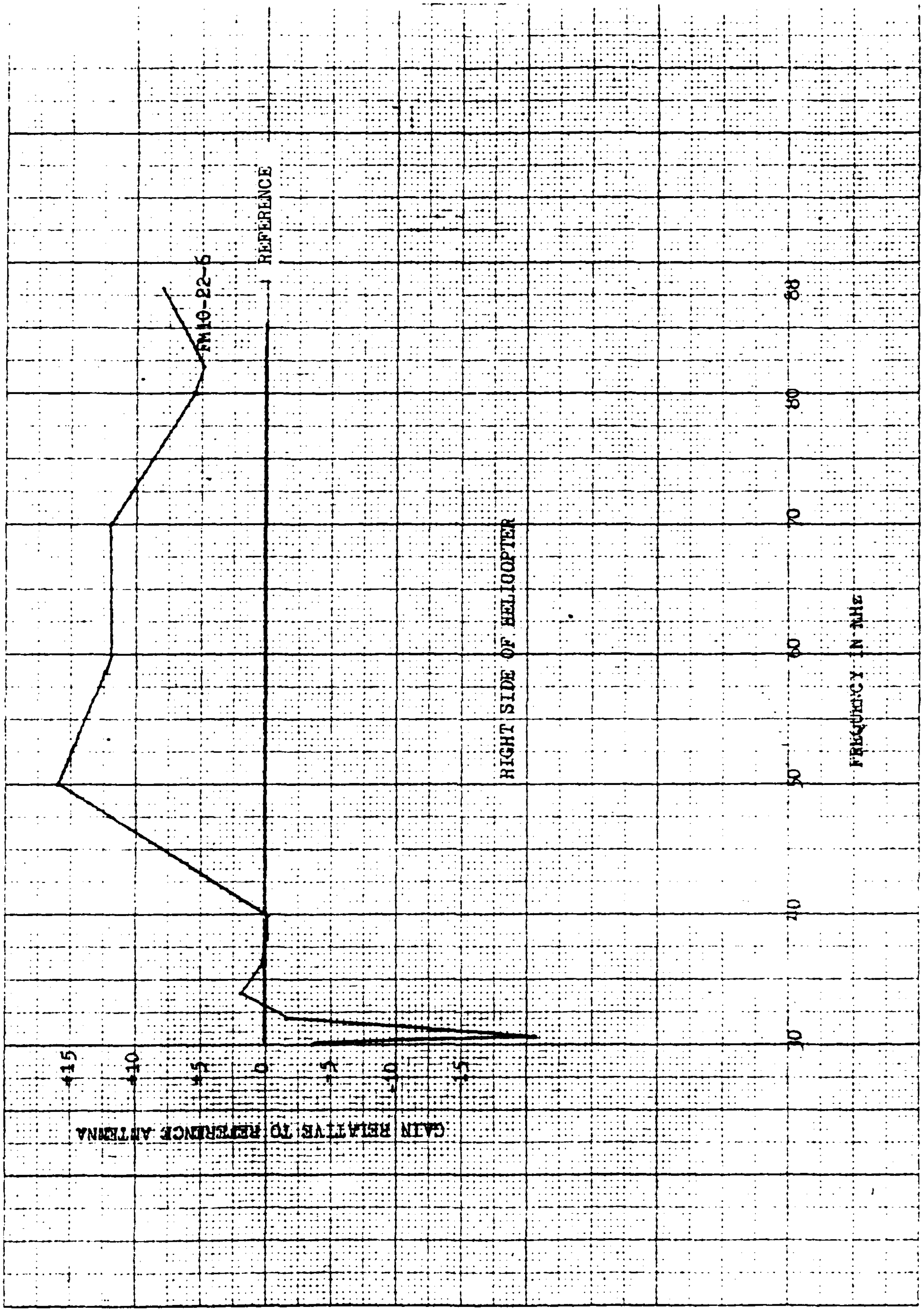
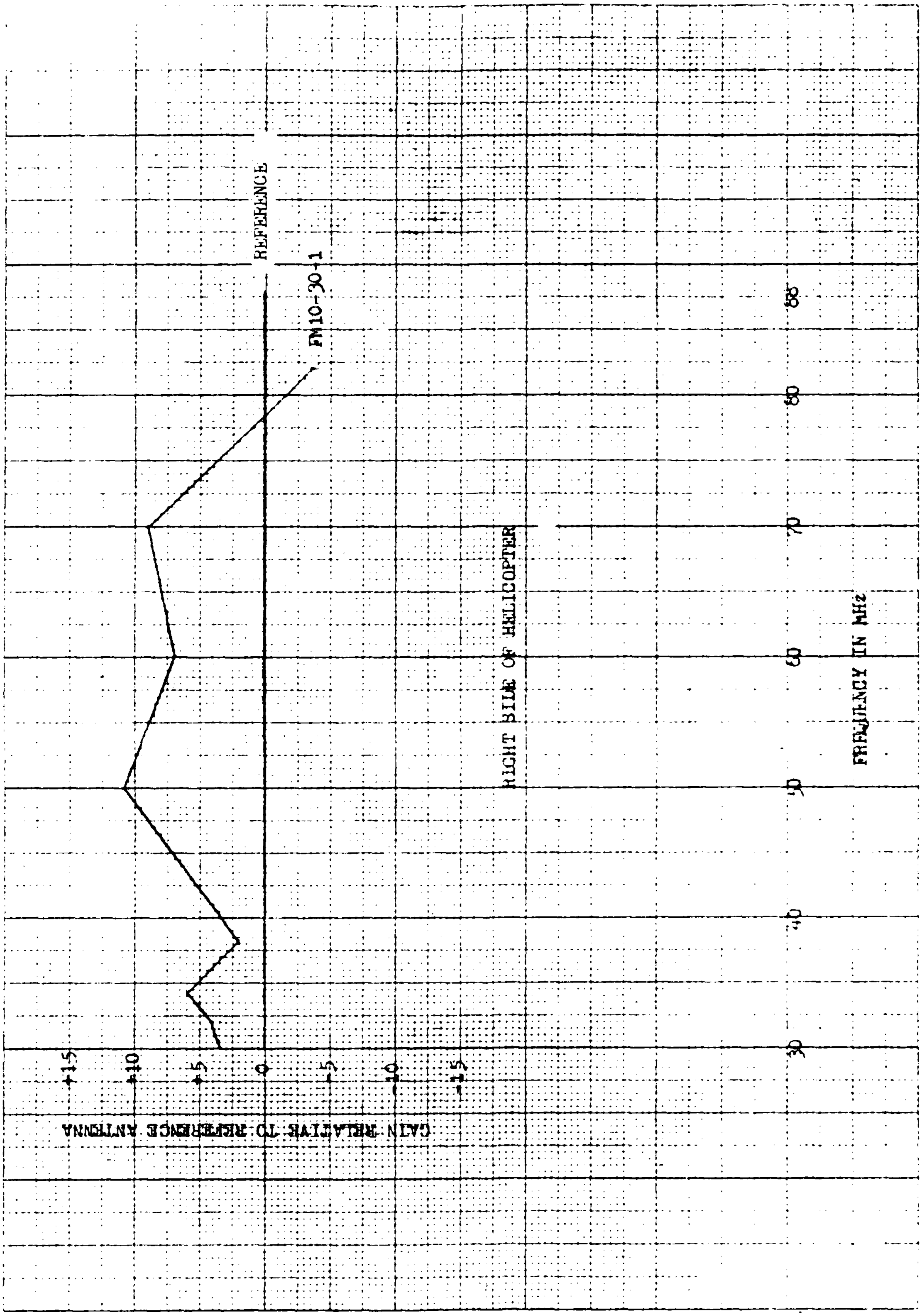
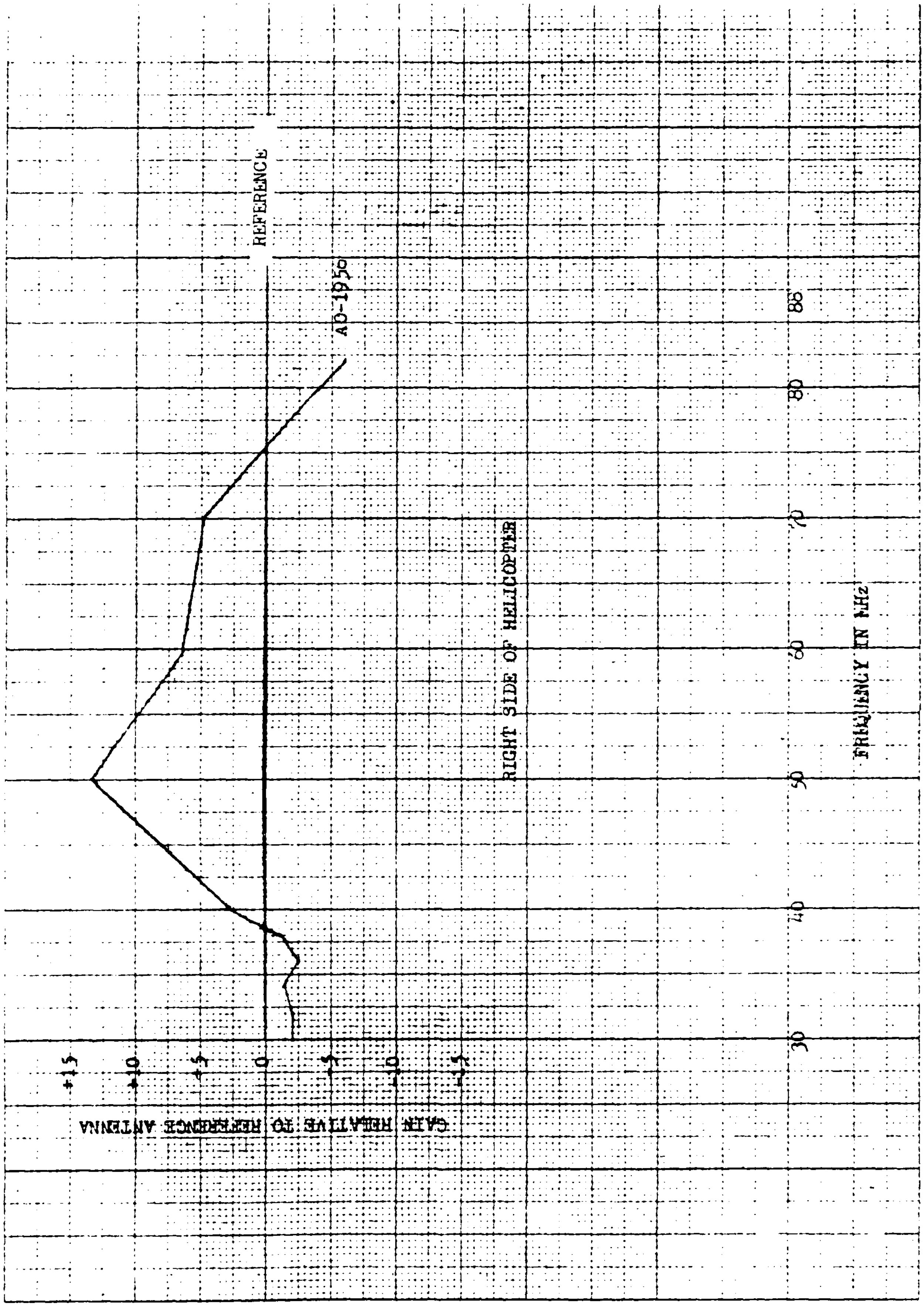
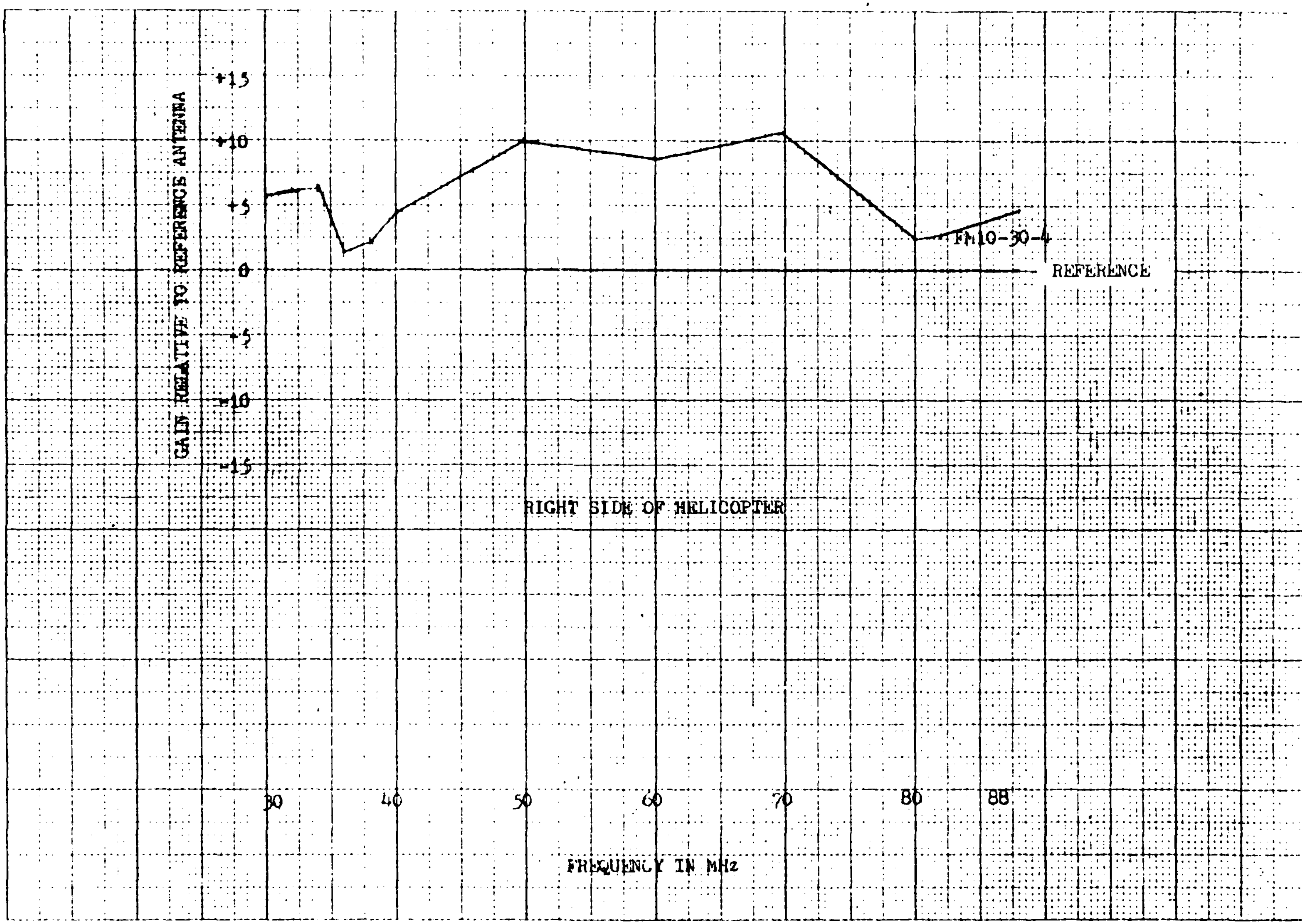
50
60
70
80
88
FREQUENCY IN MHZ

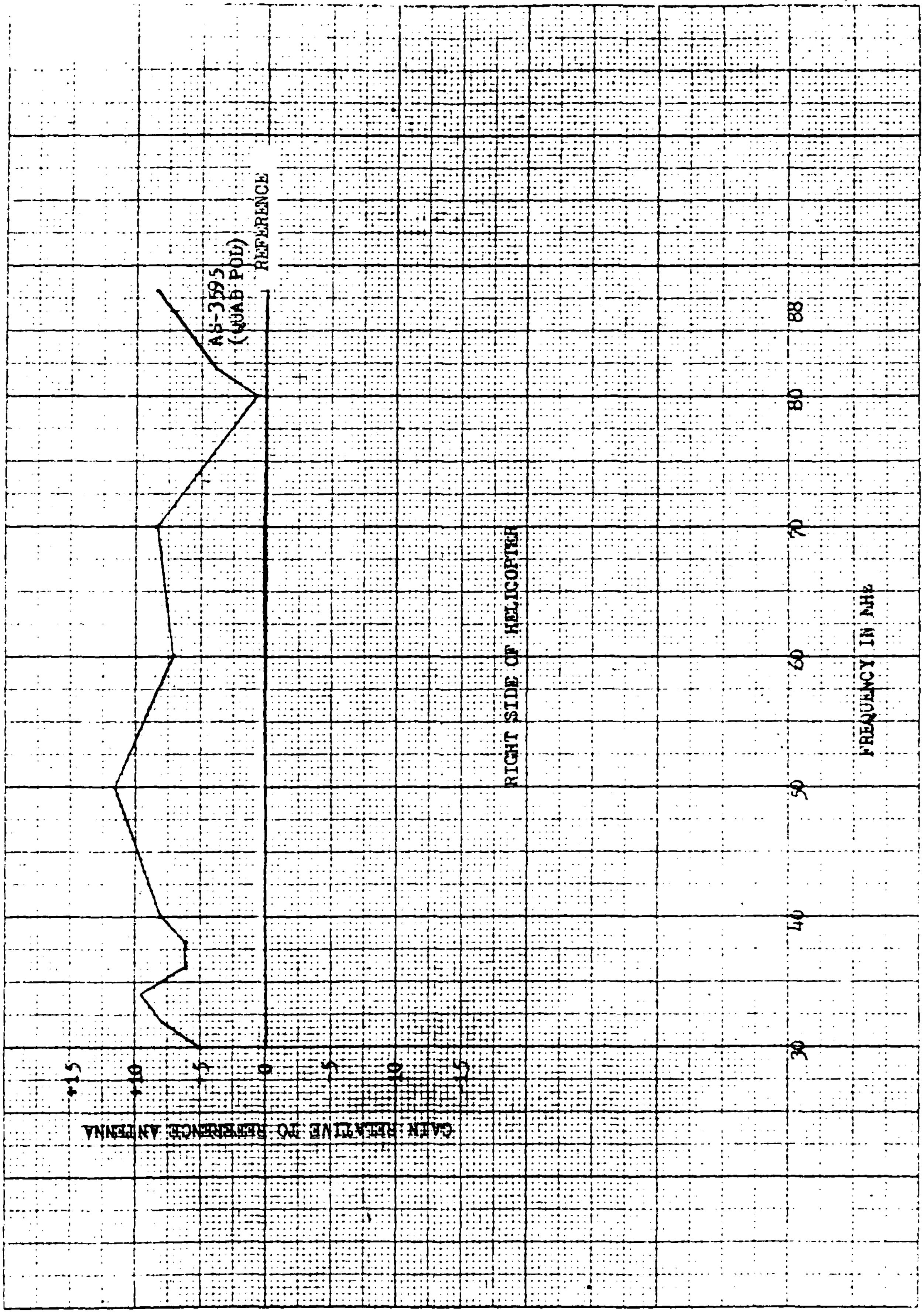


GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88
REFERENCE
RIGHT SIDE OF HELICOPTER

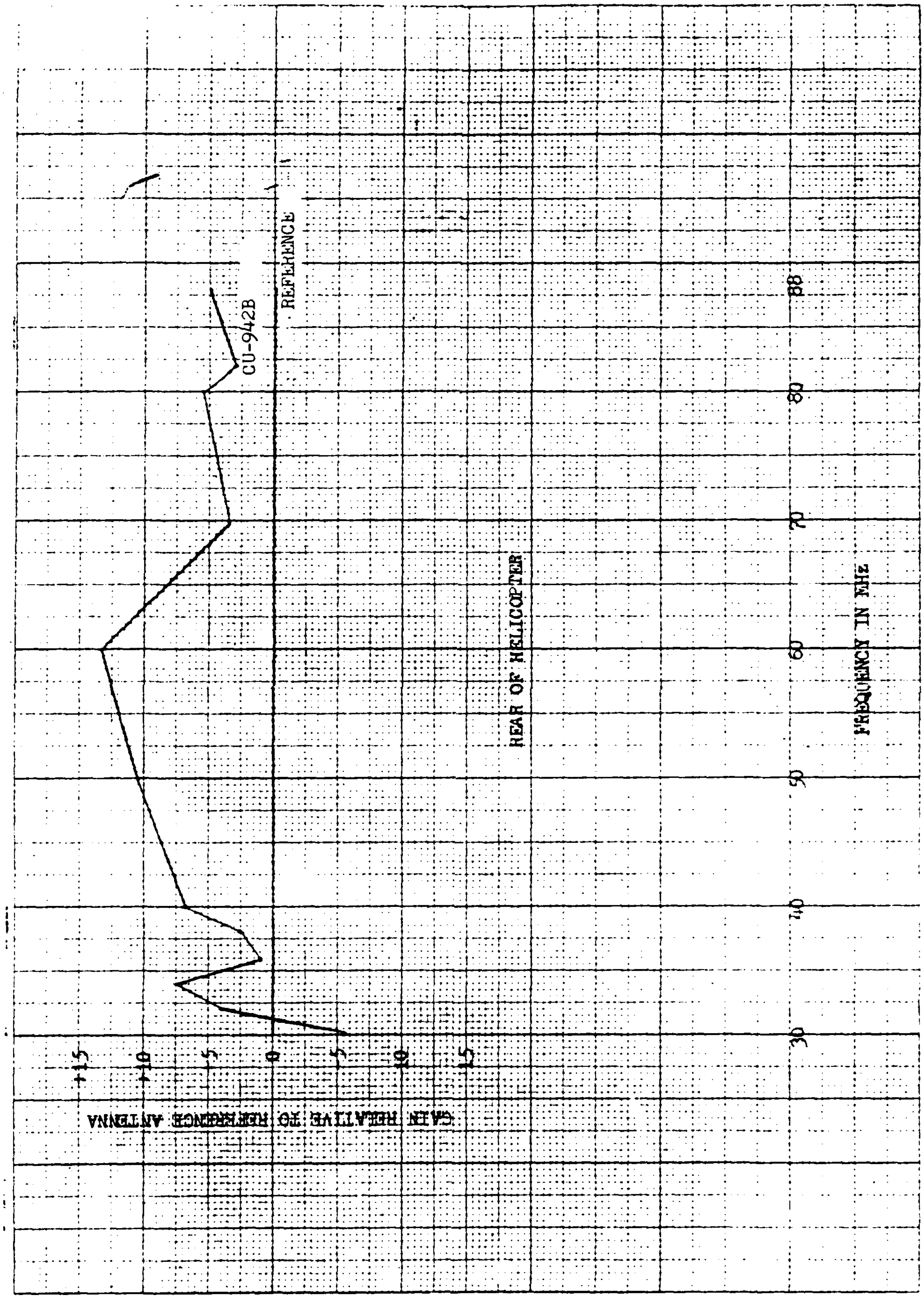

REFERENCE
FM10-30-1
RIGHT SIDE OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88


REFERENCE
AD-195o
RIGHT SIDE OF HELICOPTER
FREQUENCY IN MHz
30
40
50
60
70
80
88
+15
+10
+5
0
-5
-10
-15
GAIN RELATIVE TO REFERENCE ANTENNA

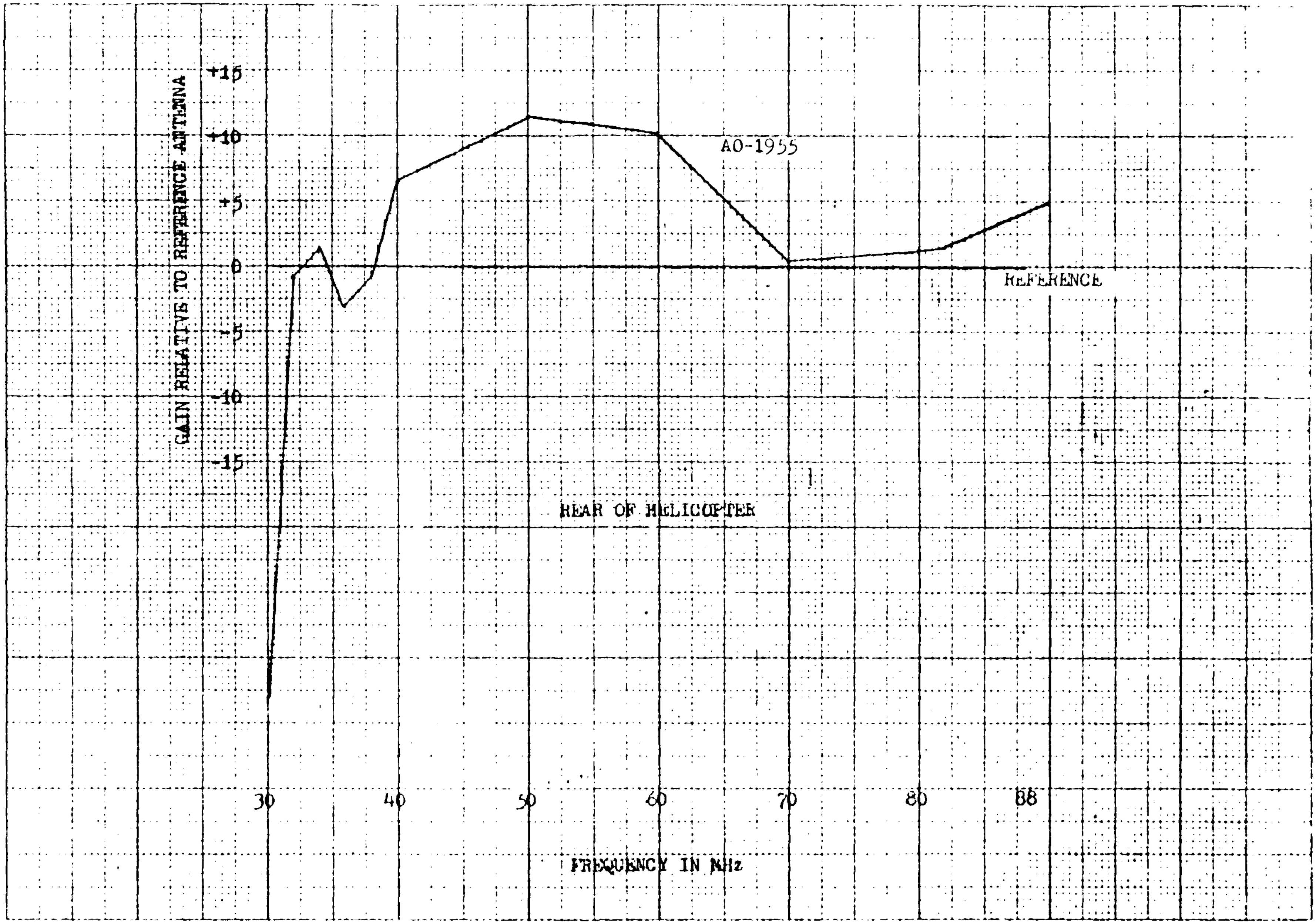

GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
FM10-30-4
REFERENCE
RIGHT SIDE OF HELICOPTER
30
40
50
60
70
80
88
FREQUENCY IN MHz


AS-3595
(QUAD POD)
REFERENCE
RIGHT SIDE OF HELICOPTER
FREQUENCY IN MHz
30
40
50
60
70
80
88
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15

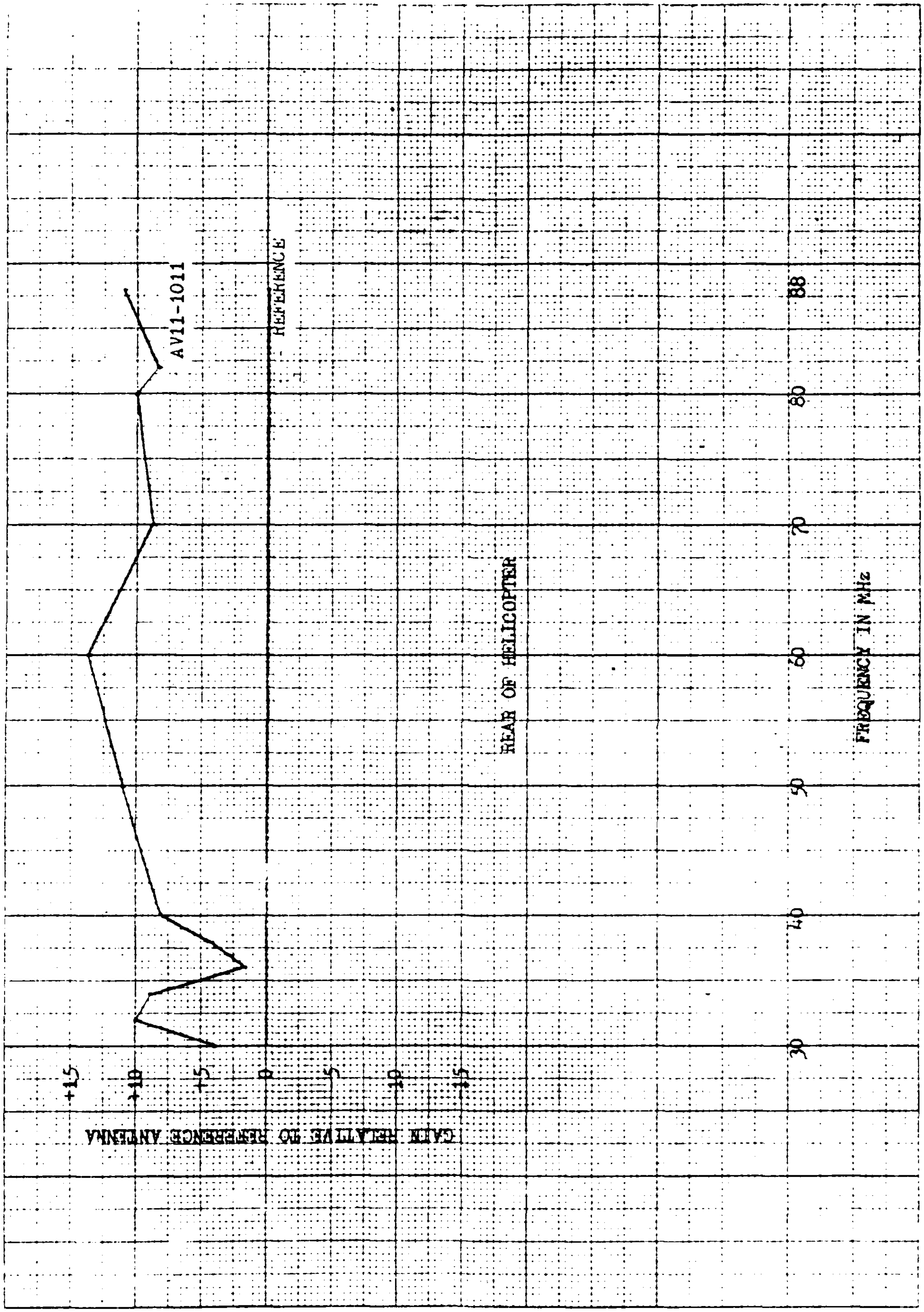
APPENDIX C. GAIN PLOTS FROM REAR OF HELICOPTER



CU-942B
REFERENCE
REAR OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
5
10
15
30
40
50
60
70
80
88


GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
A0-1955
REFERENCE
REAR OF HELICOPTER
30
40
50
60
70
80
88
FREQUENCY IN MHz


AV11-401A
REFERENCE
REAR OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88


AV11-1011
REFERENCE
REAR OF HELICOPTER
FREQUENCY IN MHz
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50
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70
80
88
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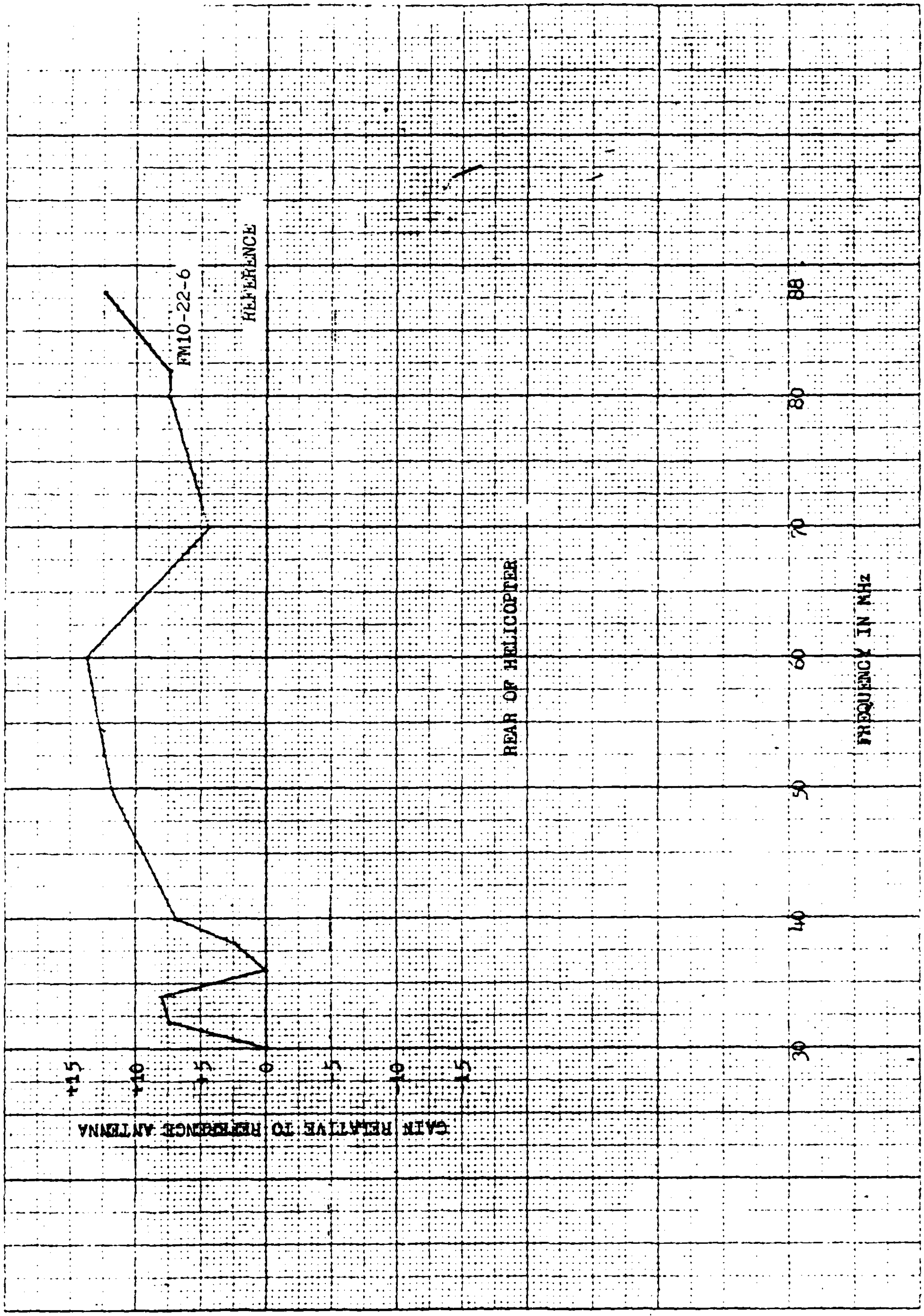
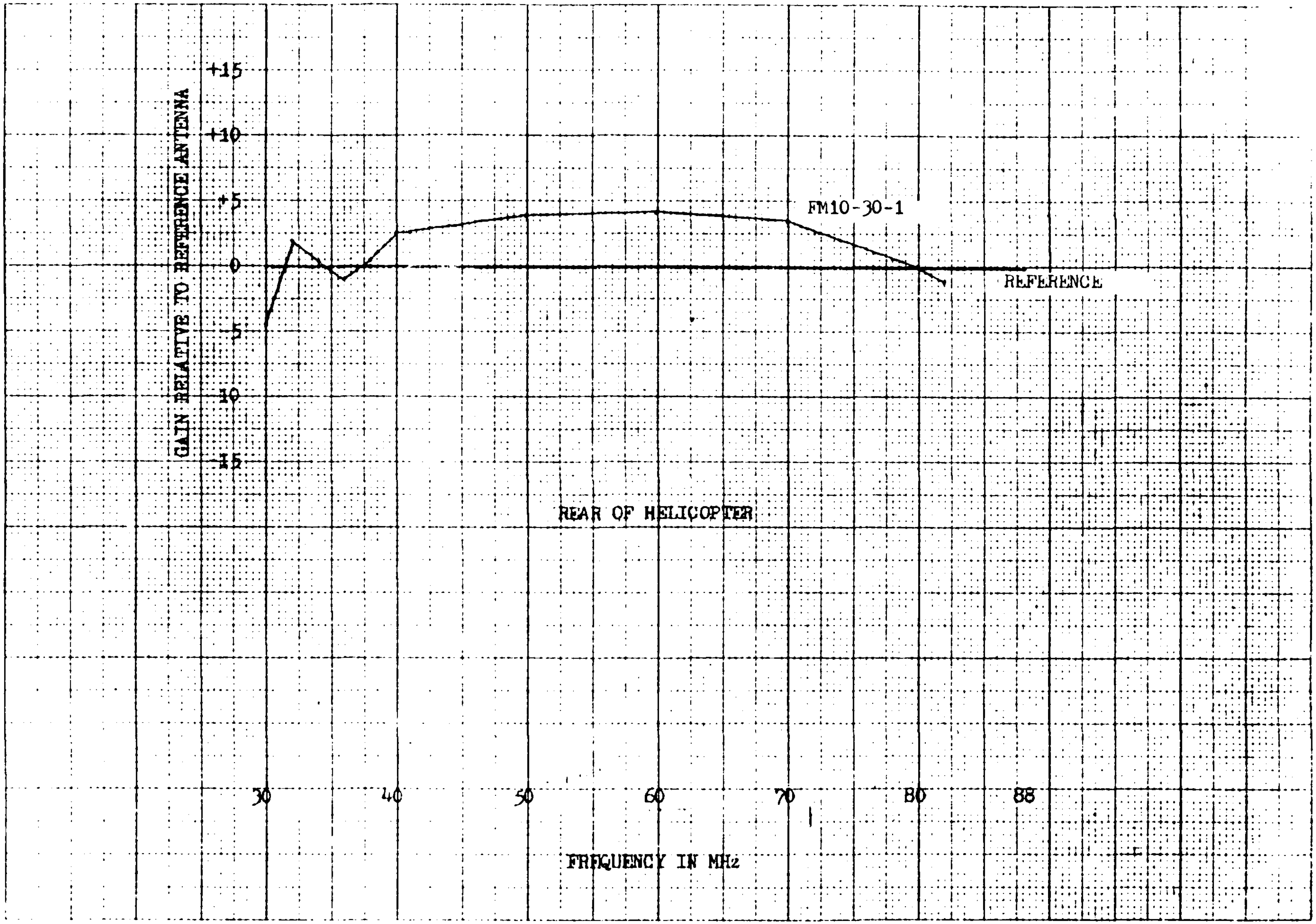
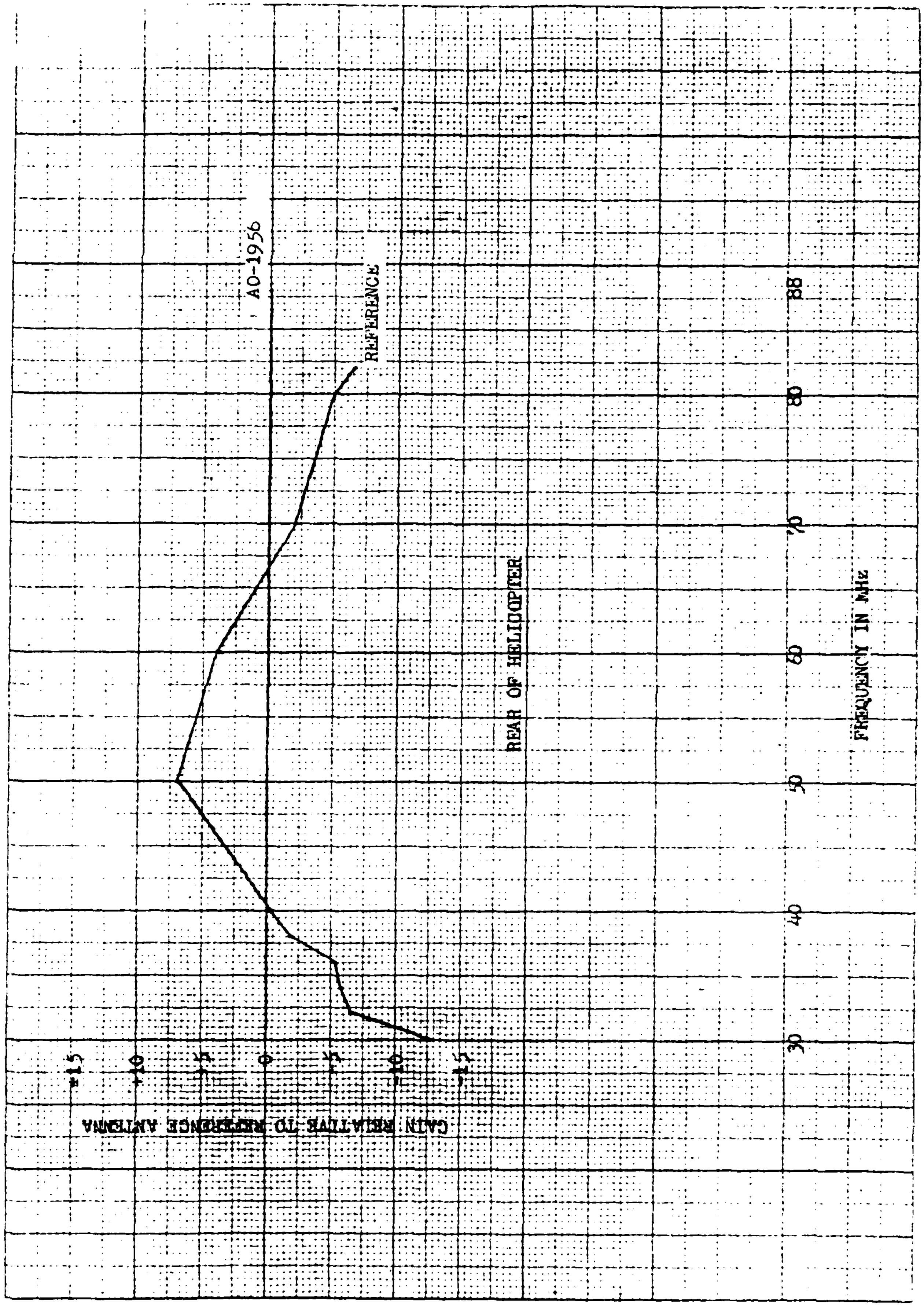
+10
+5
0
-5
-10
-15



FM10-22-6
REFERENCE
REAR OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88


GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
5
10
15
FM10-30-1
REFERENCE
REAR OF HELICOPTER
30
40
50
60
70
80
88
FREQUENCY IN MHz



A0-1956
REFERENCE
REAR OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
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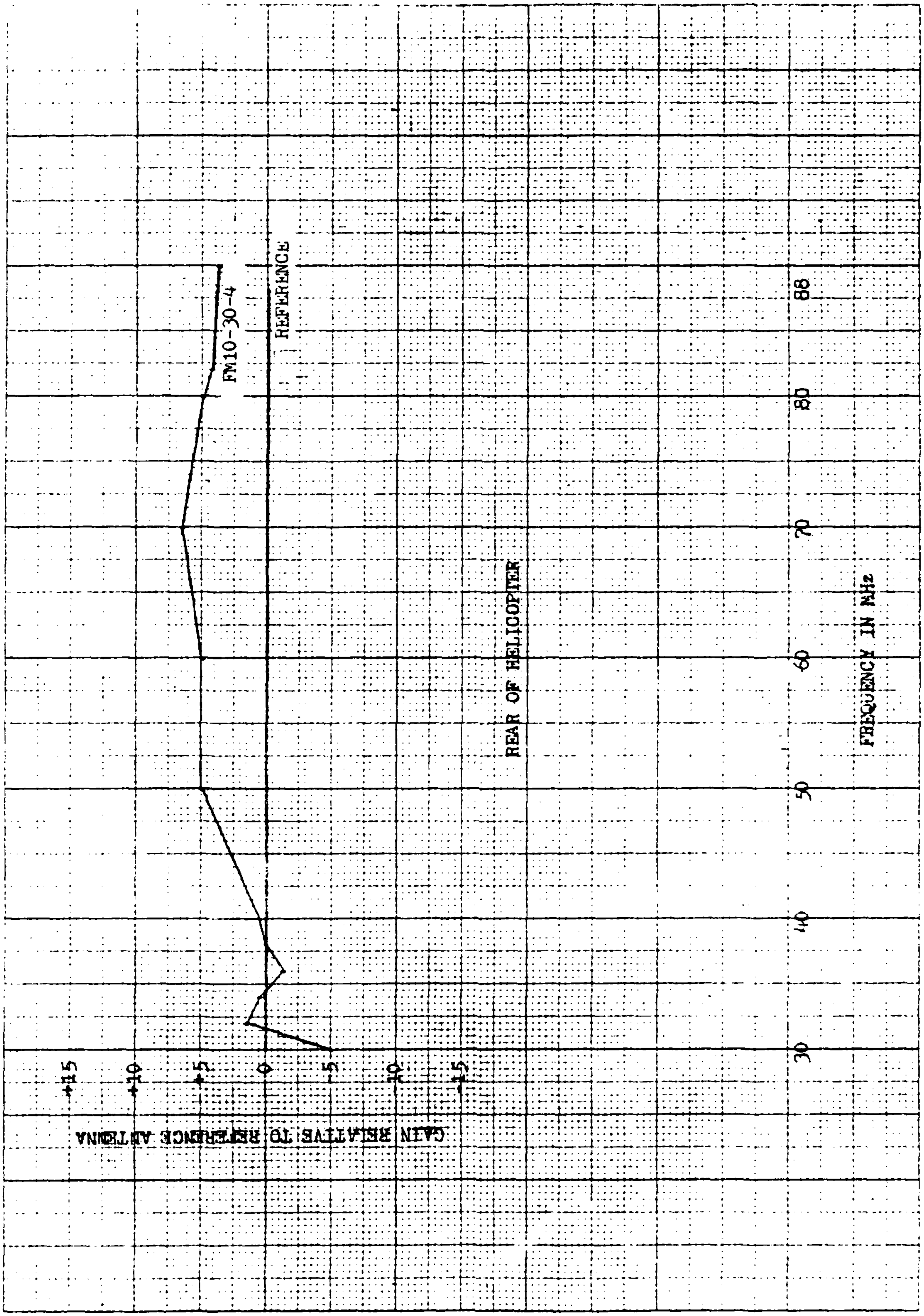
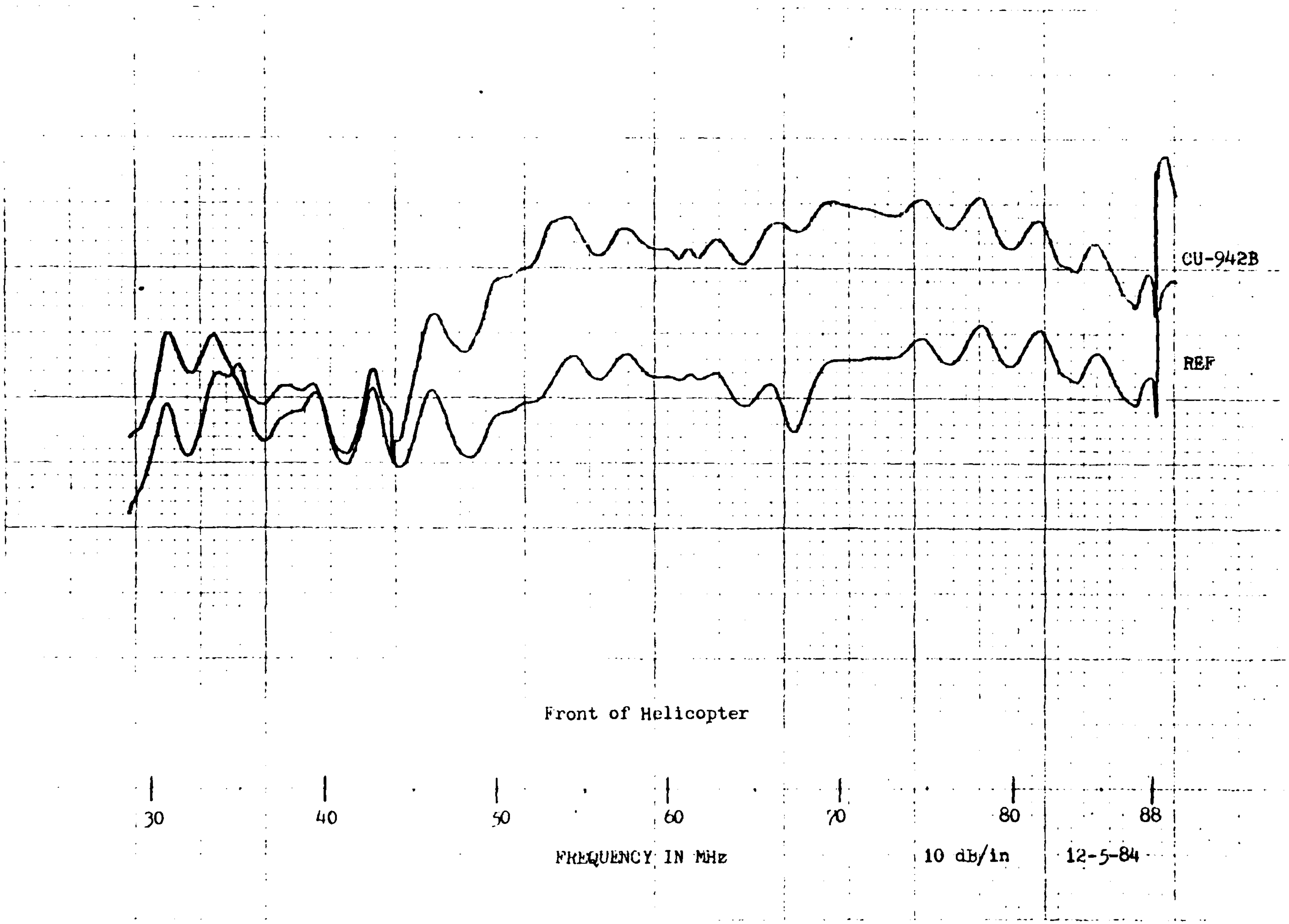
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88

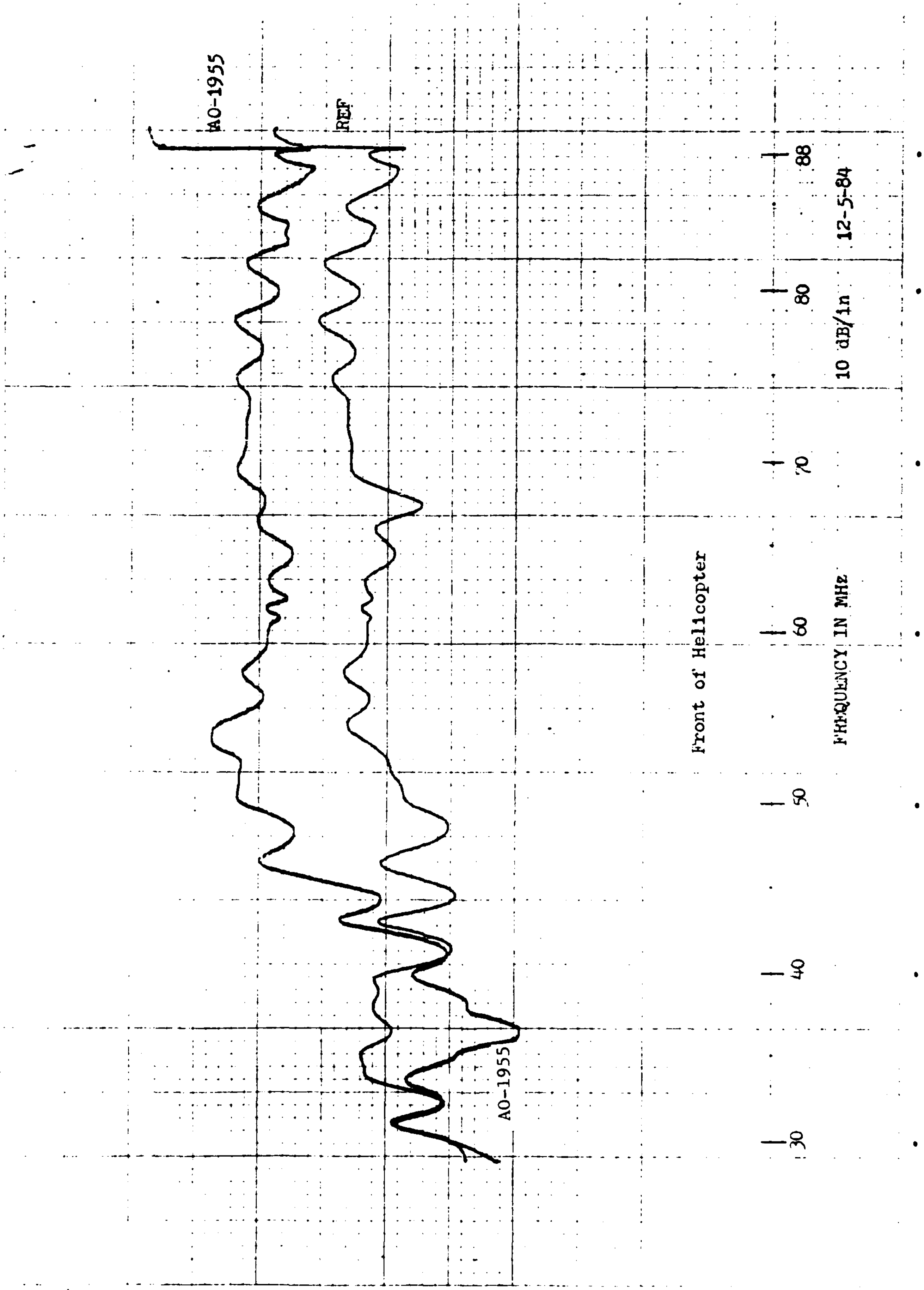


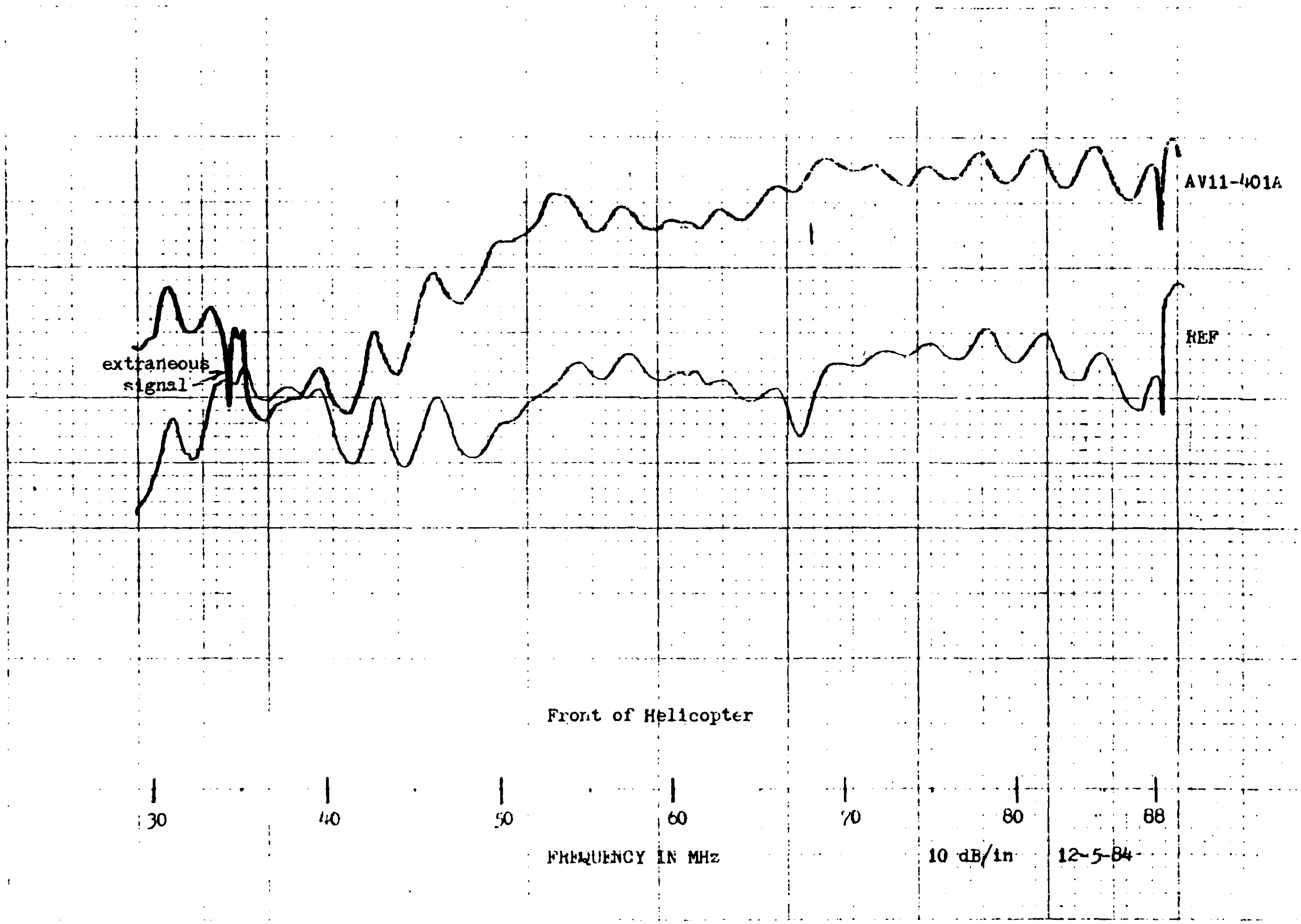
FM10-30-4
REFERENCE
REAR OF HELICOPTER
FREQUENCY IN MHz
30
40
50
60
70
80
88
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15


REFERENCE
AS-3595
REAR OF HELICOPTER
FREQUENCY IN MHz
GAIN RELATIVE TO REFERENCE ANTENNA
+15
+10
+5
0
-5
-10
-15
30
40
50
60
70
80
88

APPENDIX D. SWEPT PATTERNS FROM FRONT OF HELICOPTER


CU-942B
REF
Front of Helicopter
30
40
50
60
70
80
88
FREQUENCY IN MHz
10 dB/in
12-5-84


AO-1955
REF
AO-1955
88
80
70
60
50
40
30
12-5-84
10 dB/in
Front of Helicopter
FREQUENCY IN MHz


AV11-401A
REF
extraneous
signal
Front of Helicopter
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70
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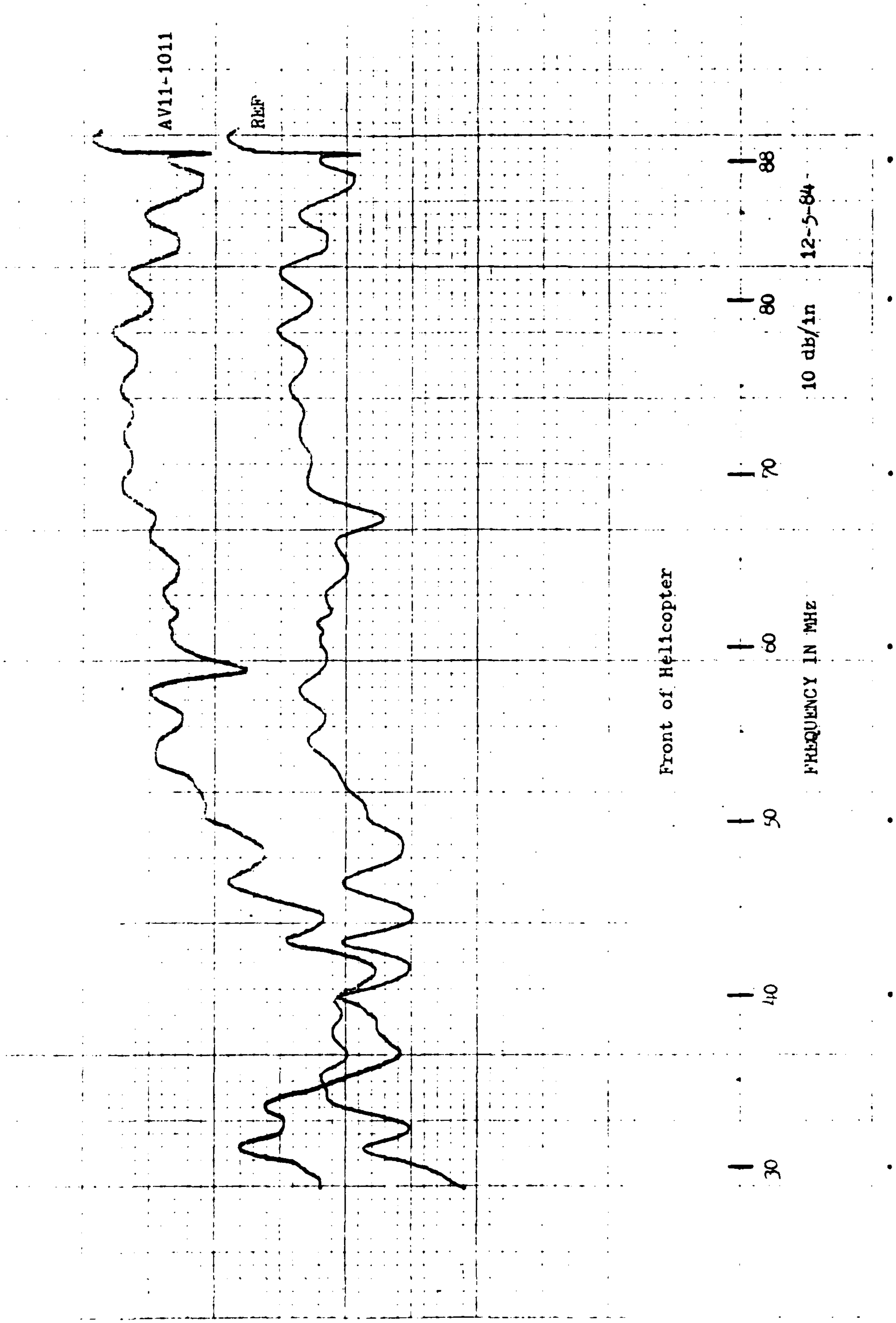
88
FREQUENCY IN MHz
10 dB/in
12-5-84


AV11-1011
REF
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FREQUENCY IN MHz
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12-5-84
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70
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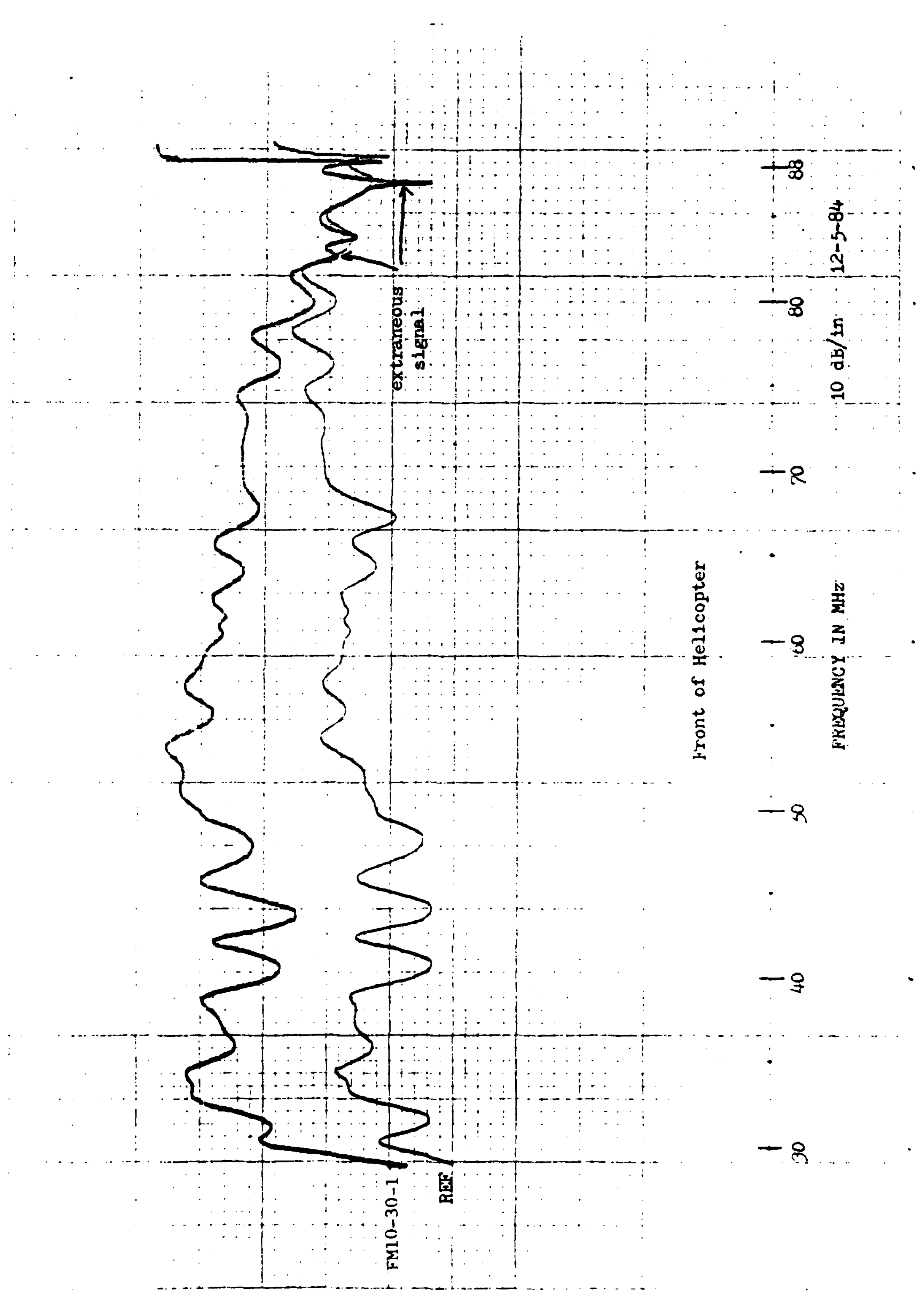
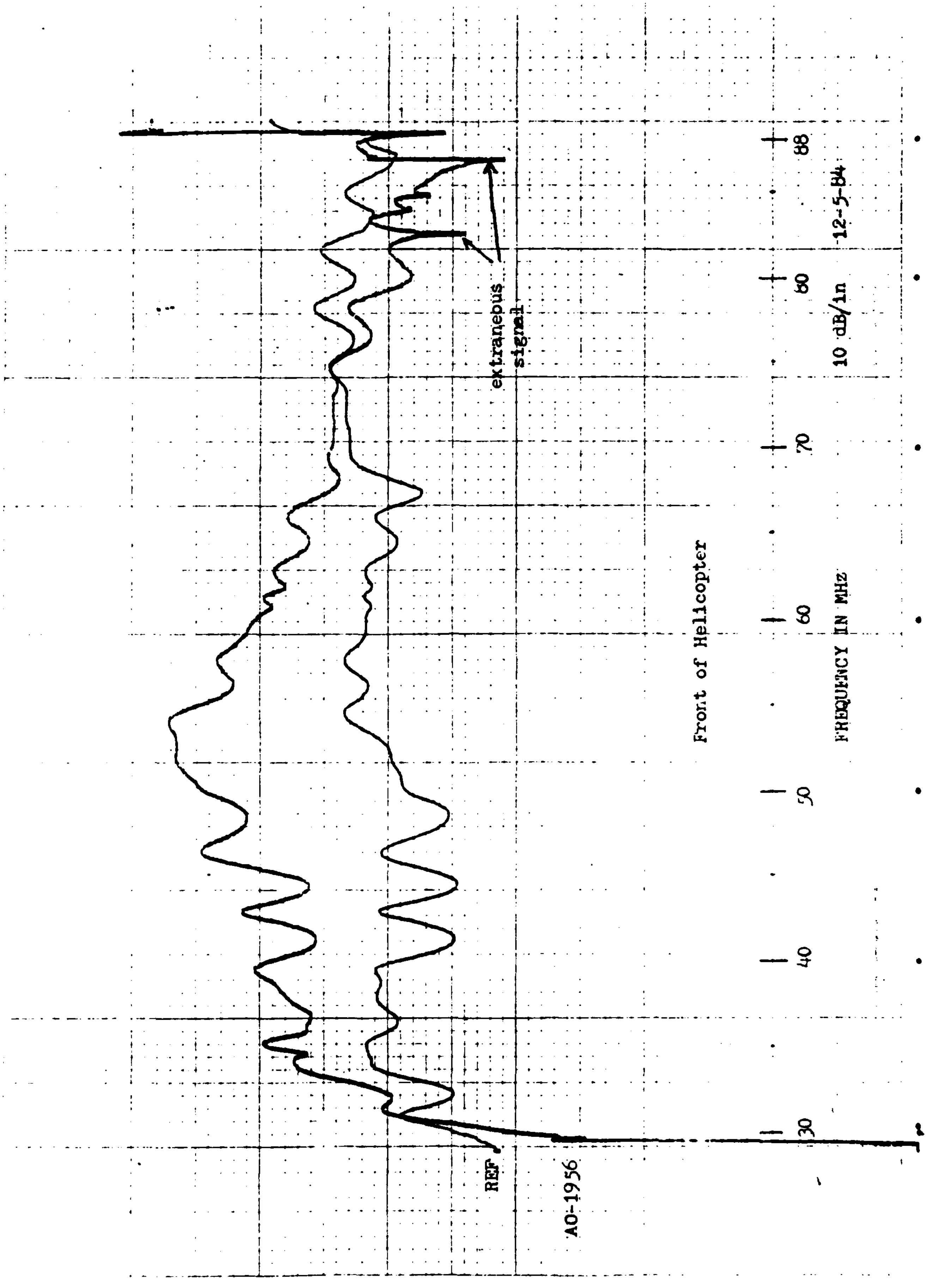
88


FM10-30-1
REF
extraneous signal
Front of Helicopter
FREQUENCY IN MHz
10 dB/in
12-5-84
30
40
50
60
70
80
88



Front of Helicopter
FREQUENCY IN MHz
10 dB/in
12-5-84
extraneous signal
REF
AO-1956
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50
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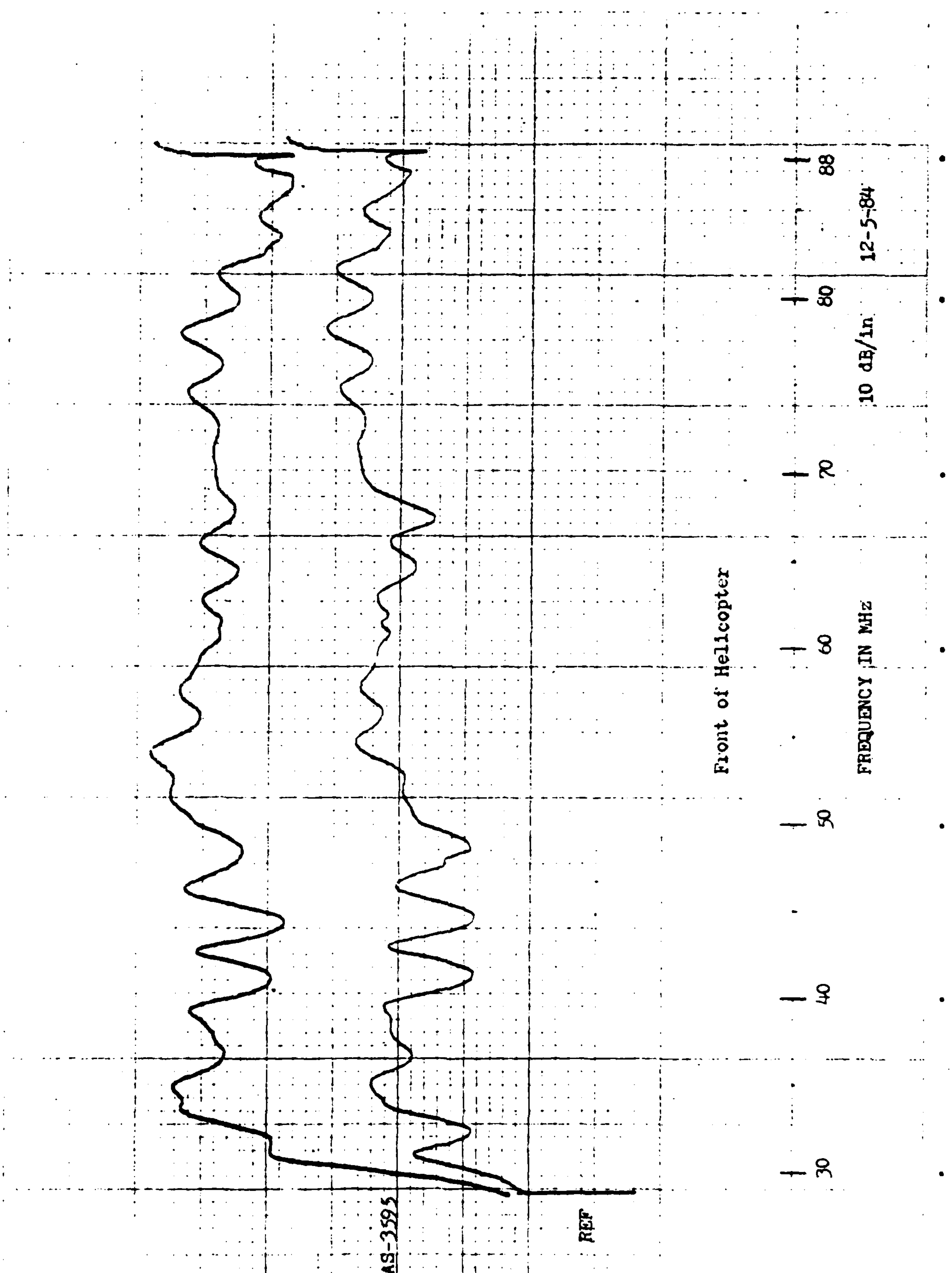
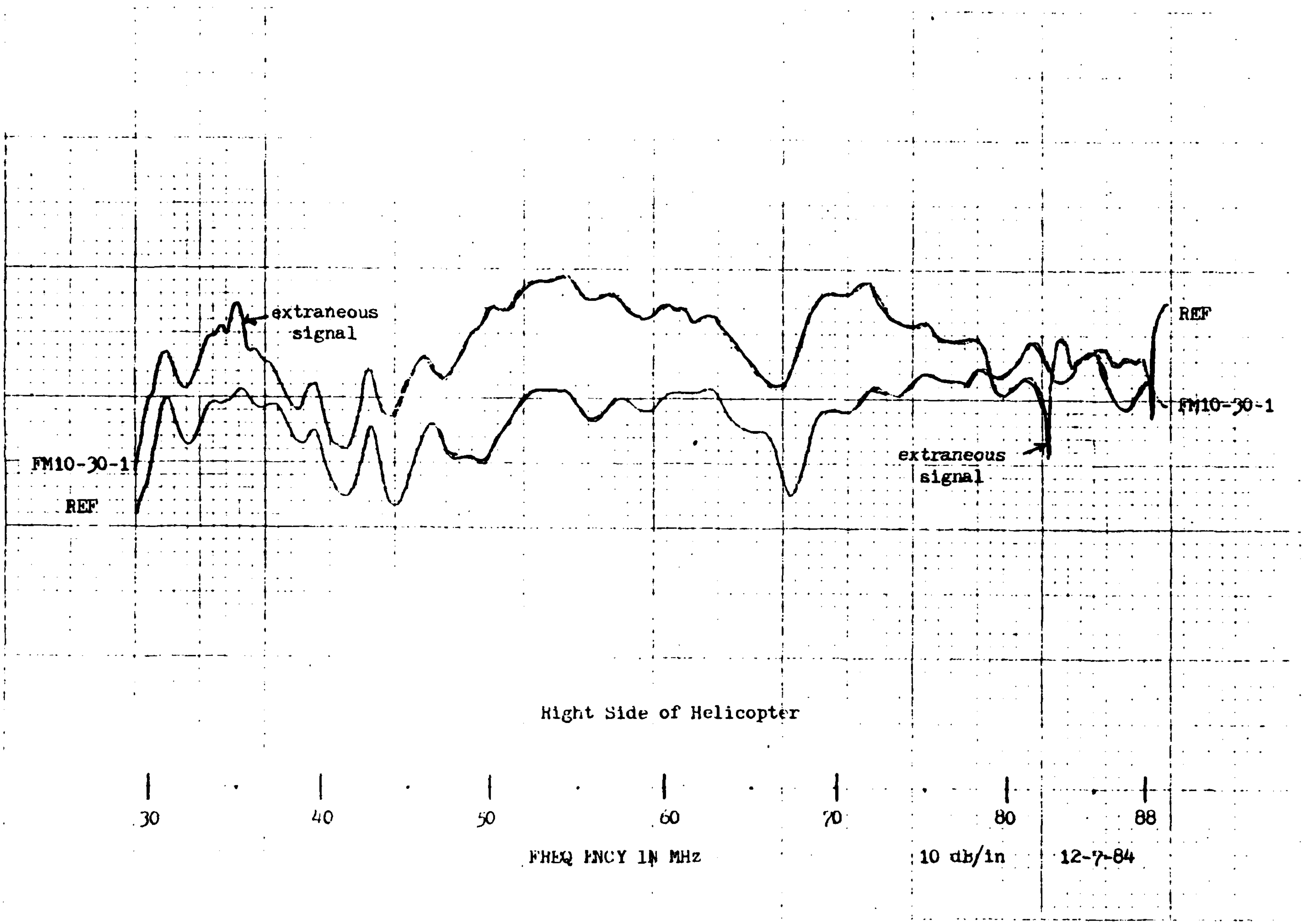
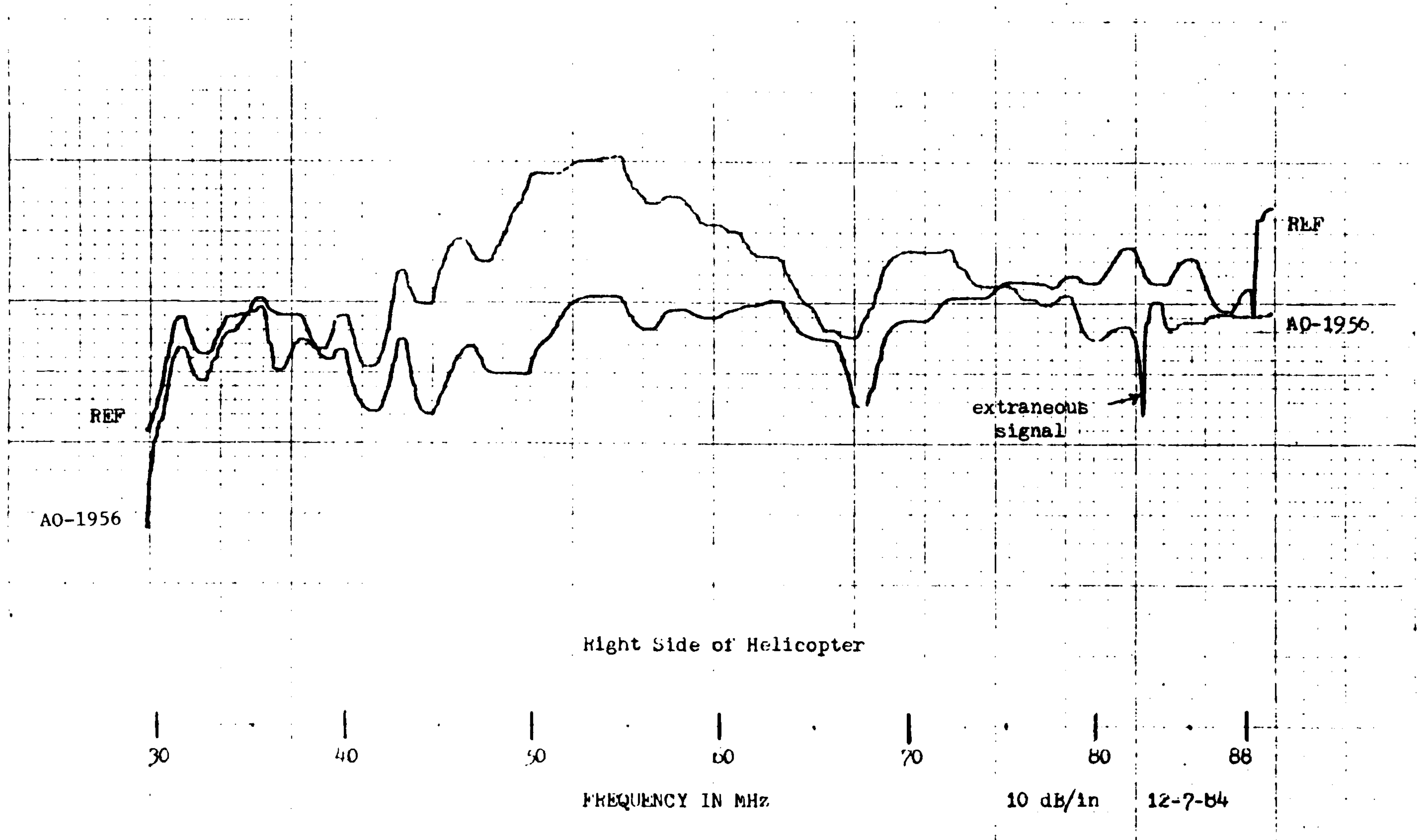
80
88



AS-3595
REF
30
40
50
60
70
80
88
Front of Helicopter
FREQUENCY IN MHz
10 dB/in
12-5-84

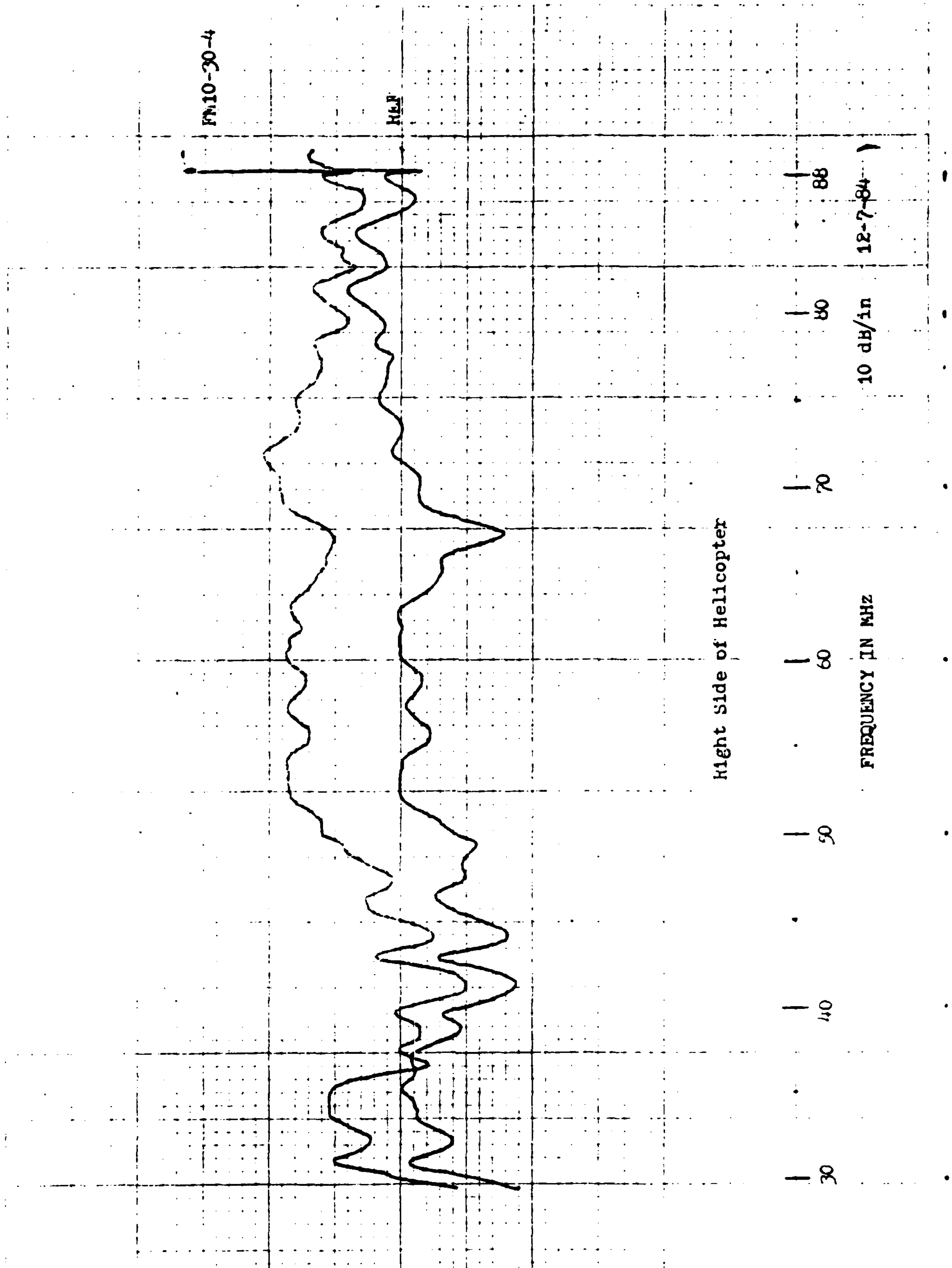
APPENDIX E. SWEPT PATTERNS FROM SIDE OF HELICOPTER

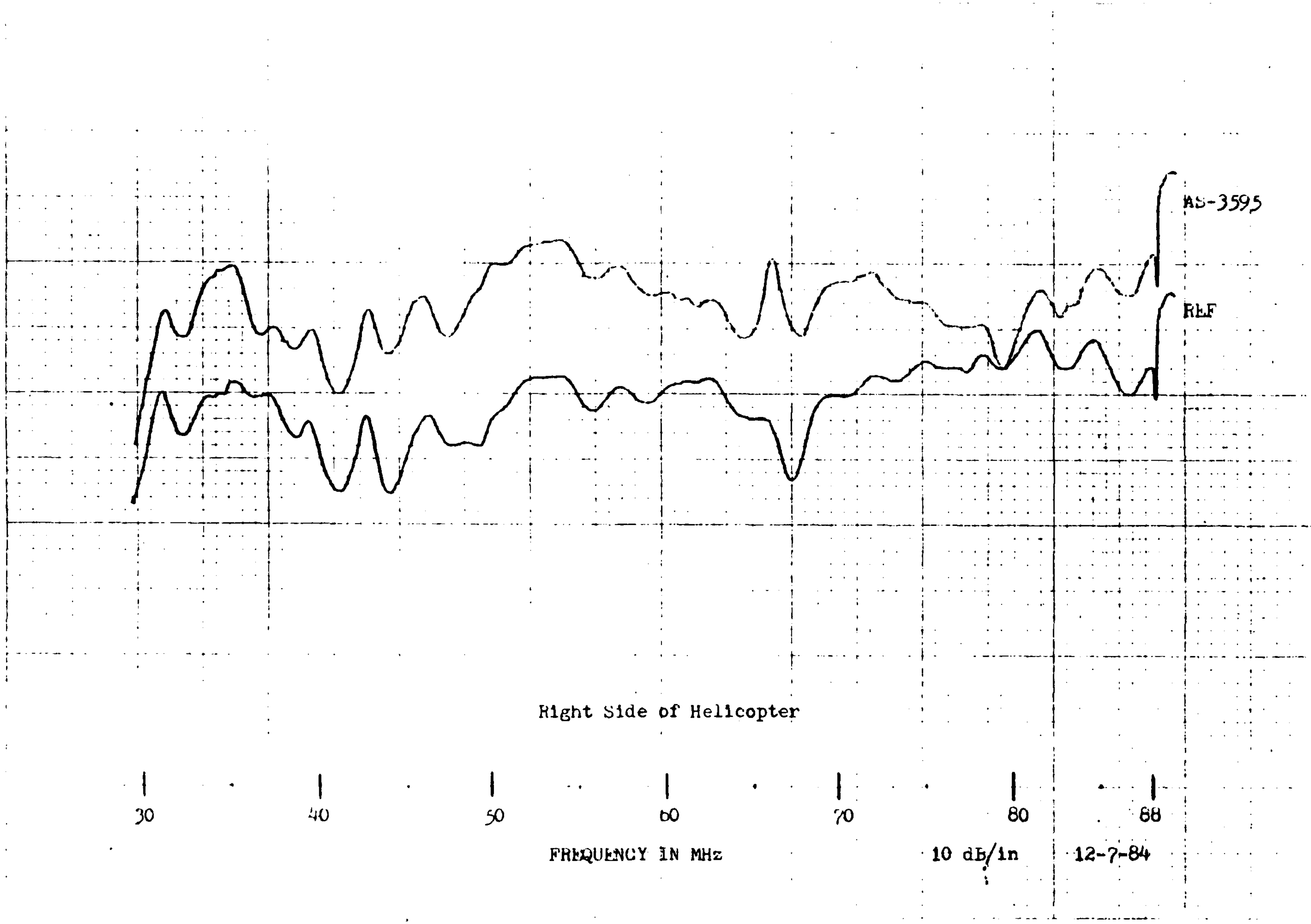

extraneous signal
REF
FM10-30-1
FM10-30-1
REF
extraneous signal
Right Side of Helicopter
30
40
50
60
70
80
88
FREQ ENCY IN MHz
10 db/in
12-7-84



Right Side of Helicopter

FREQUENCY IN MHz


FM10-30-4
12-7-84
10 dB/in
Right Side of Helicopter
FREQUENCY IN MHz
30
40
50
60
70
80
88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REF
Right Side of Helicopter
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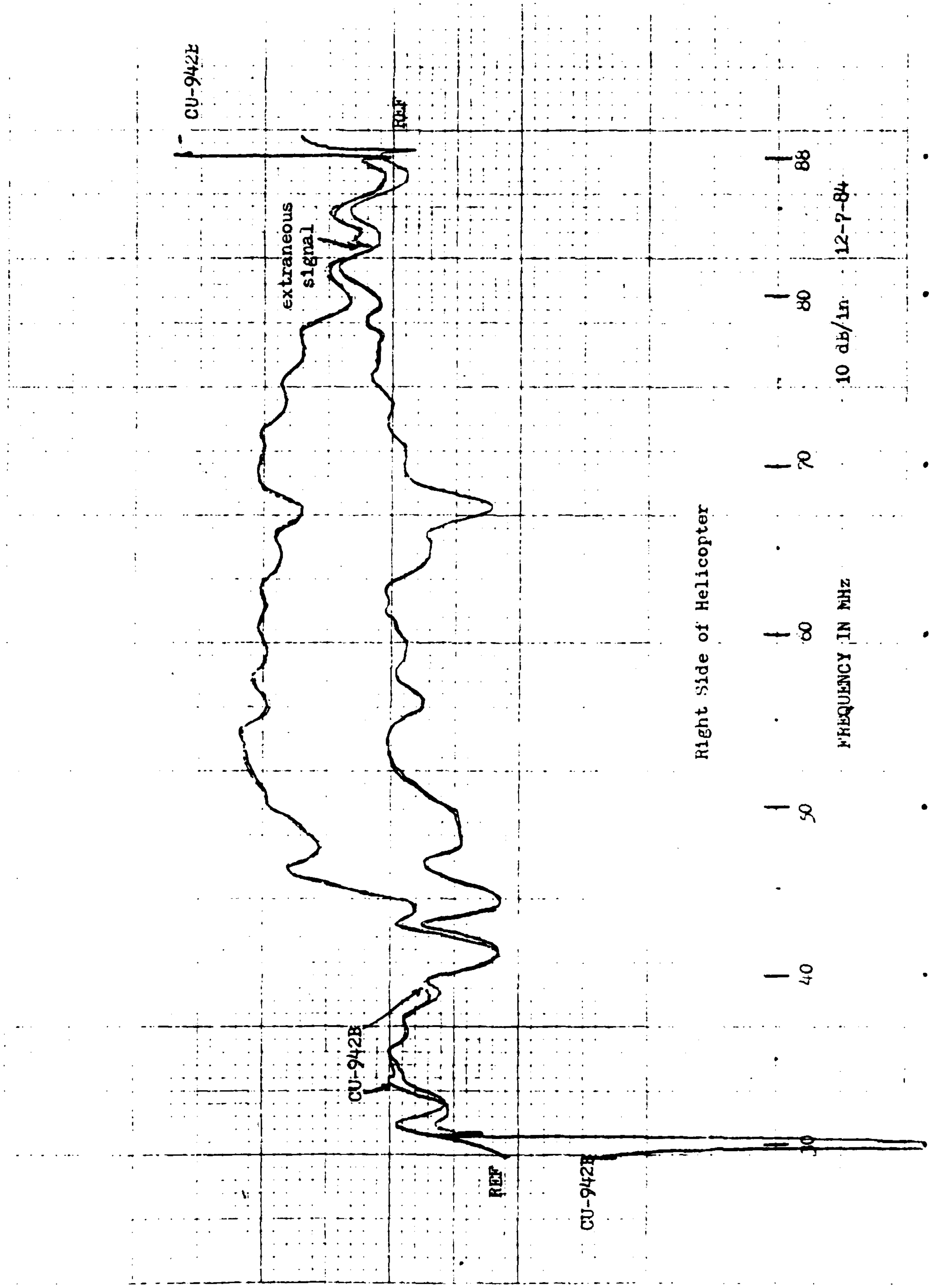
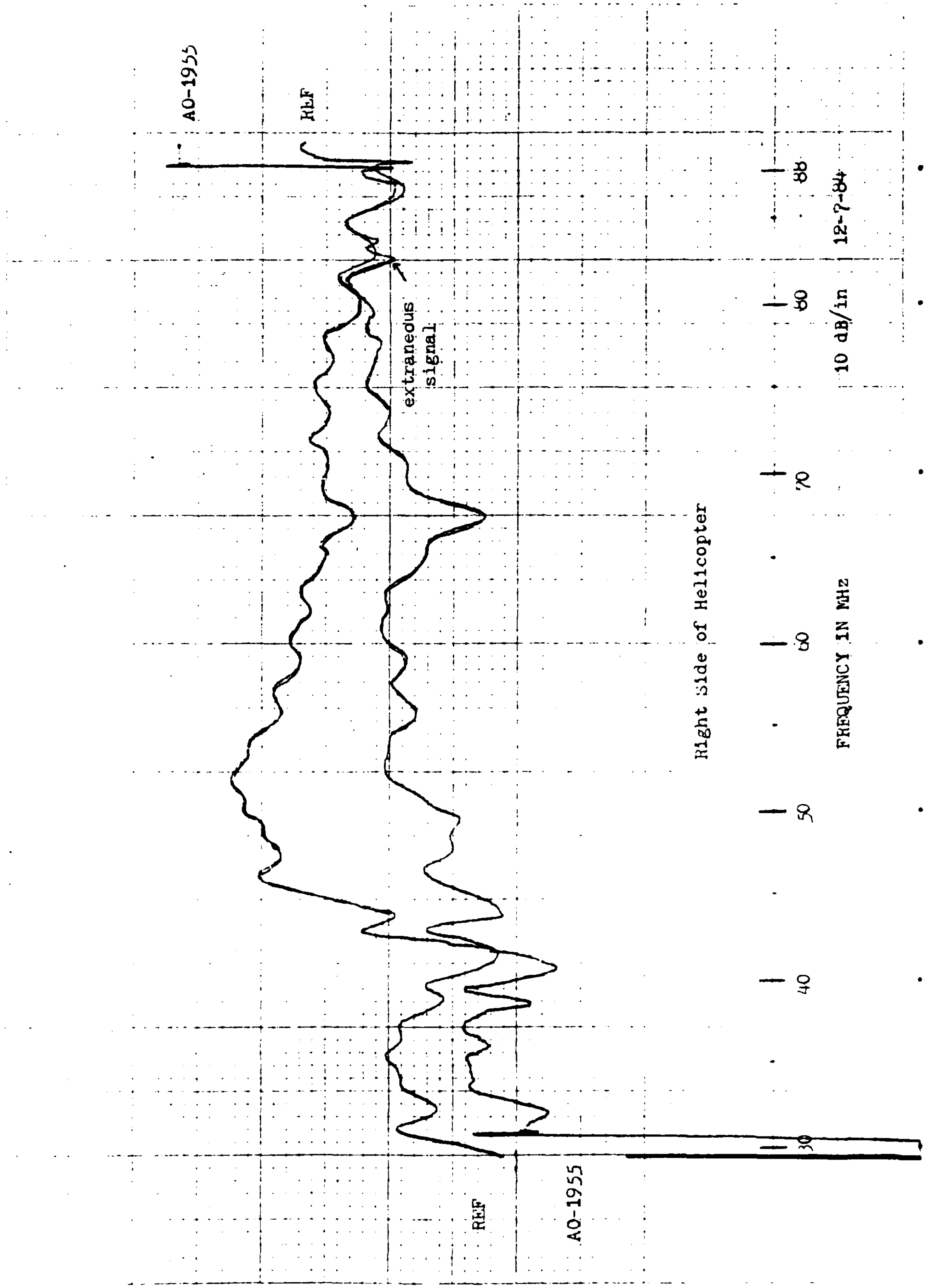
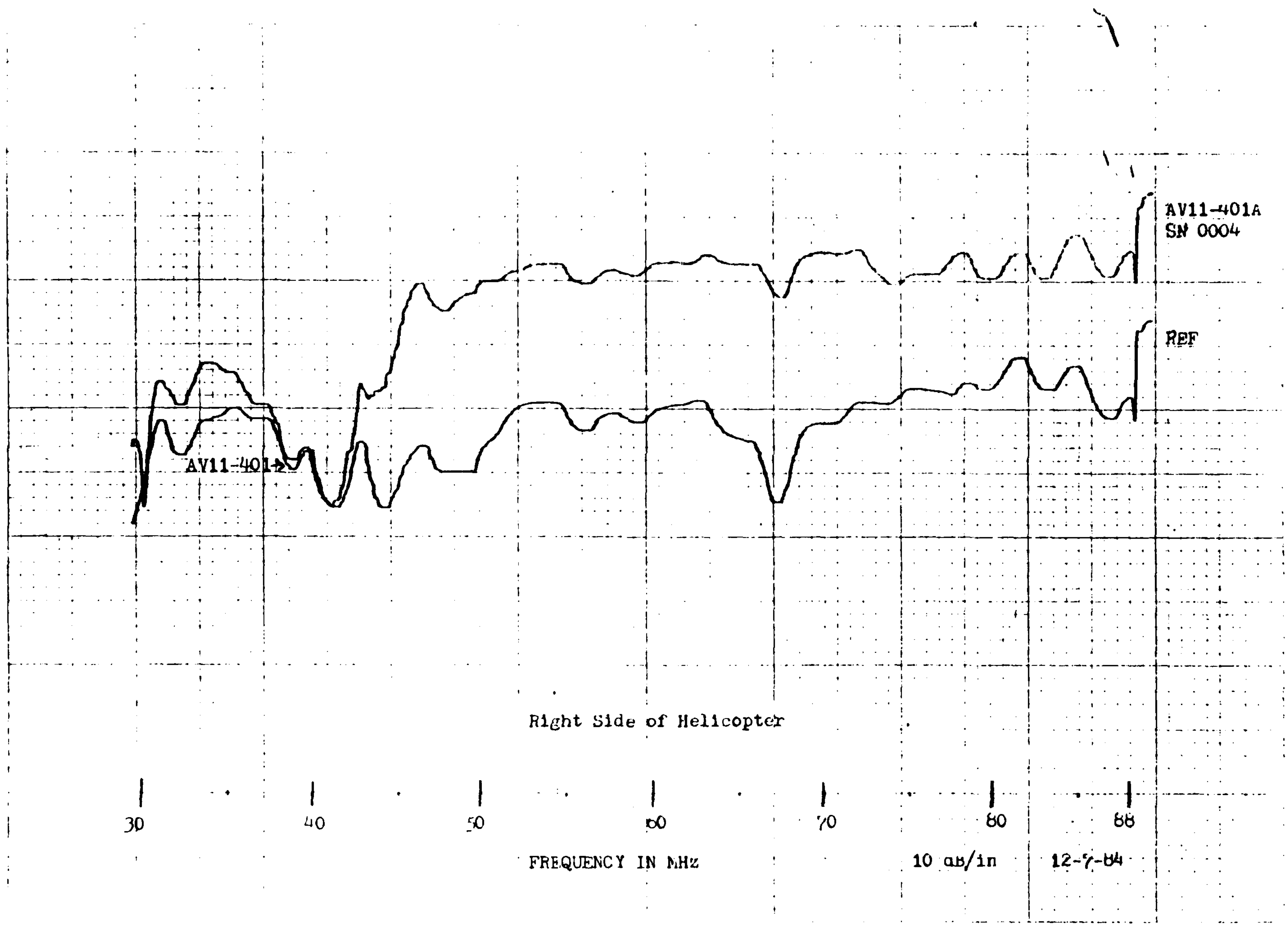
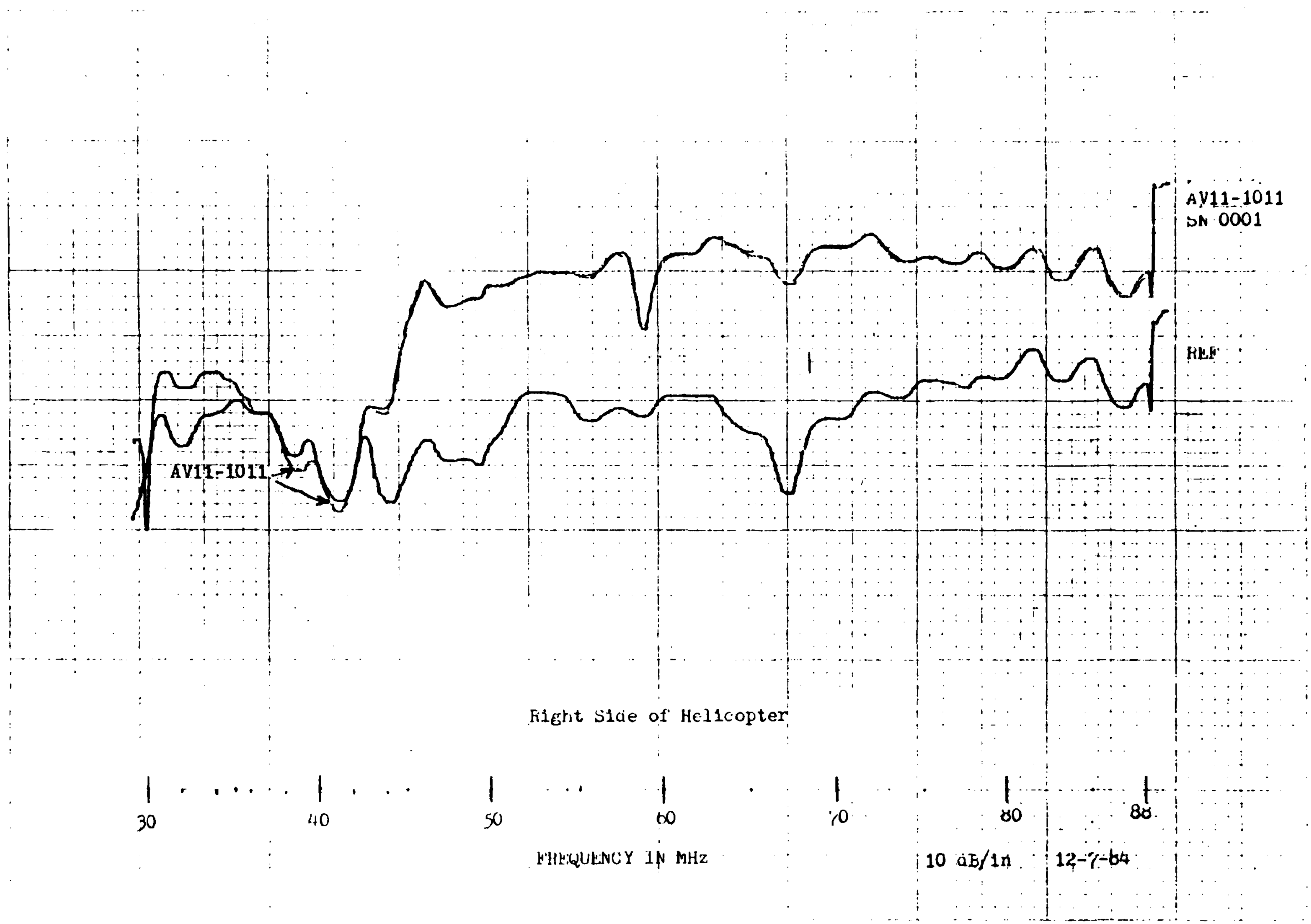
40
50
60
70
80
88
FREQUENCY IN MHz
10 dB/in
12-7-84

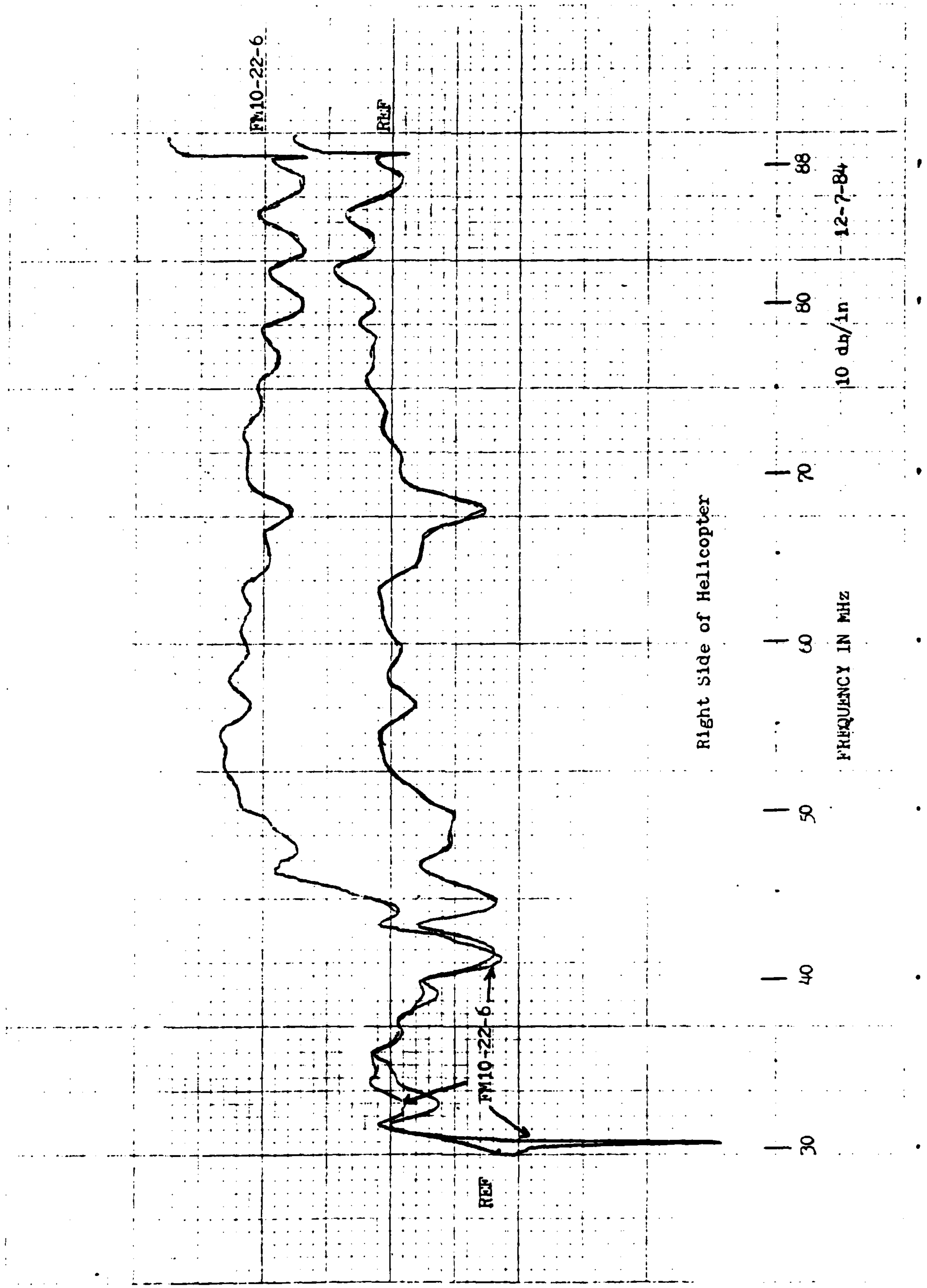

CU-942E
REF
extraneous signal
88
12-7-84
80
10 db/in
70
Right Side of Helicopter
60
FREQUENCY IN MHz
50
40
CU-942B
CU-942B
30
REF
CU-942B


AO-1955
REF
extraneous signal
Right Side of Helicopter
FREQUENCY IN MHz
10 dB/in
12-7-84
30
40
50
60
70
80
88
REF
AO-1955

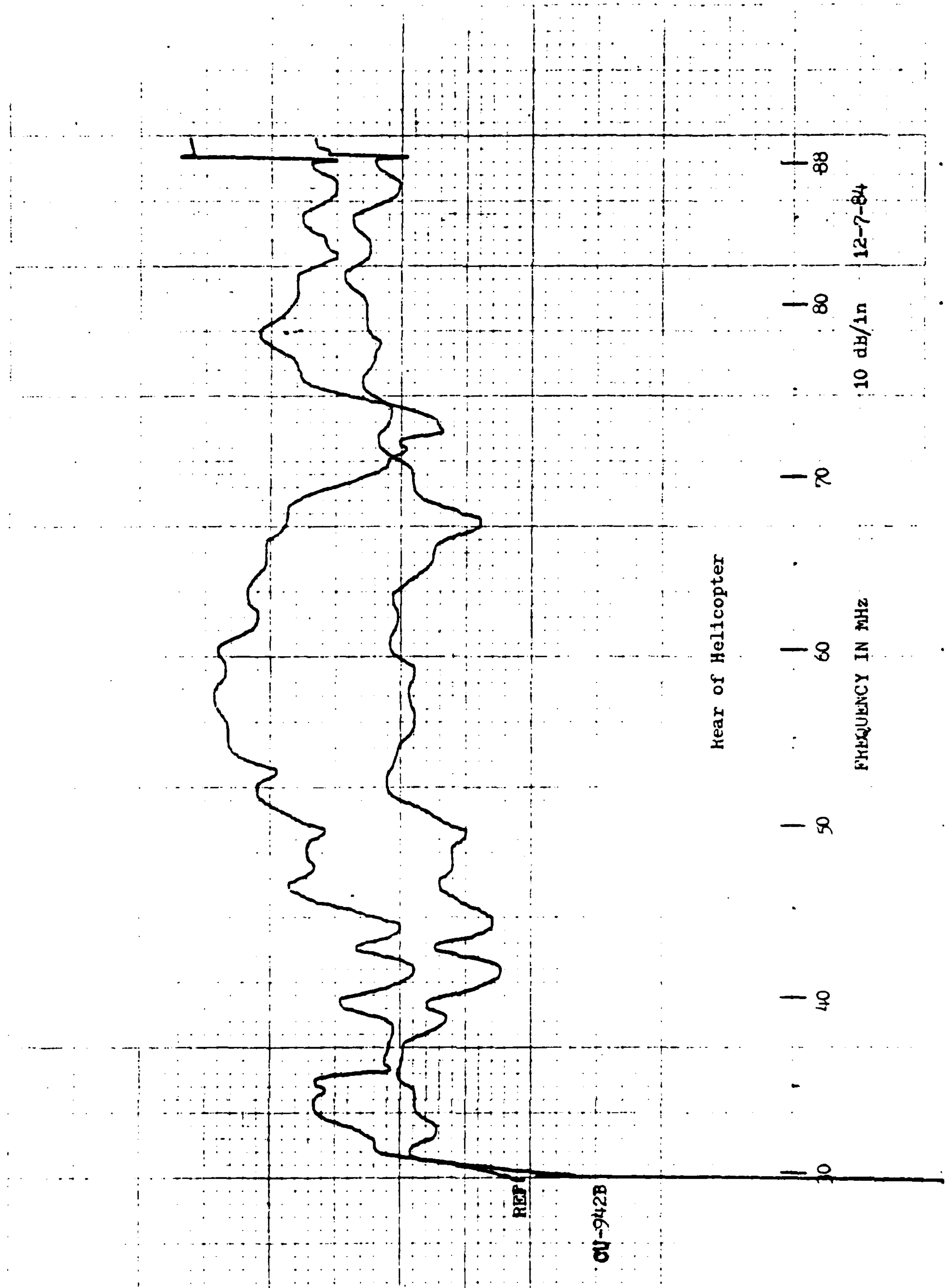


Right Side of Helicopter

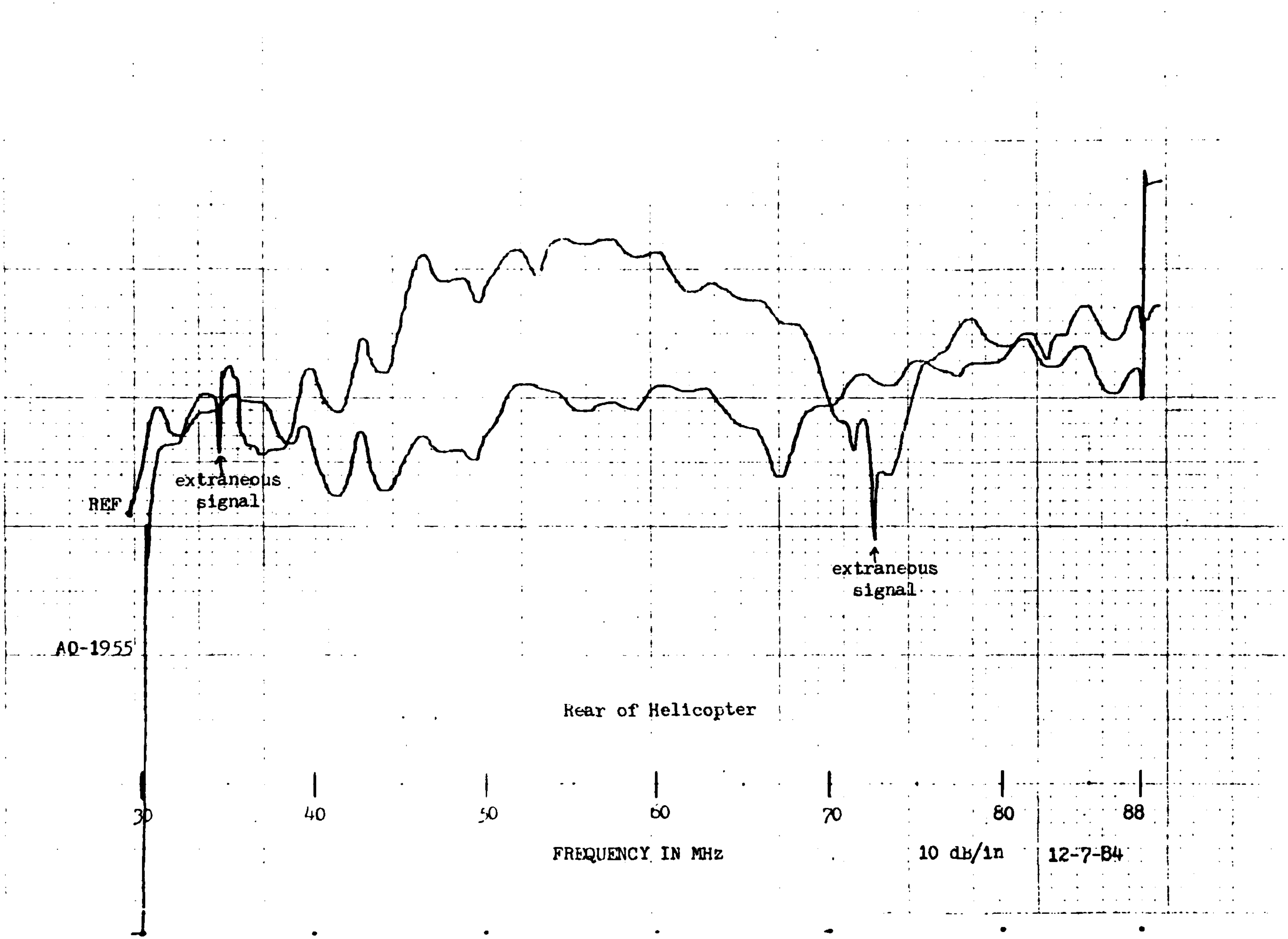

AV11-1011
SN 0001
REF
AV11-1011
Right Side of Helicopter
30
40
50
60
70
80
88
FREQUENCY IN MHz
10 dB/in
12-7-84

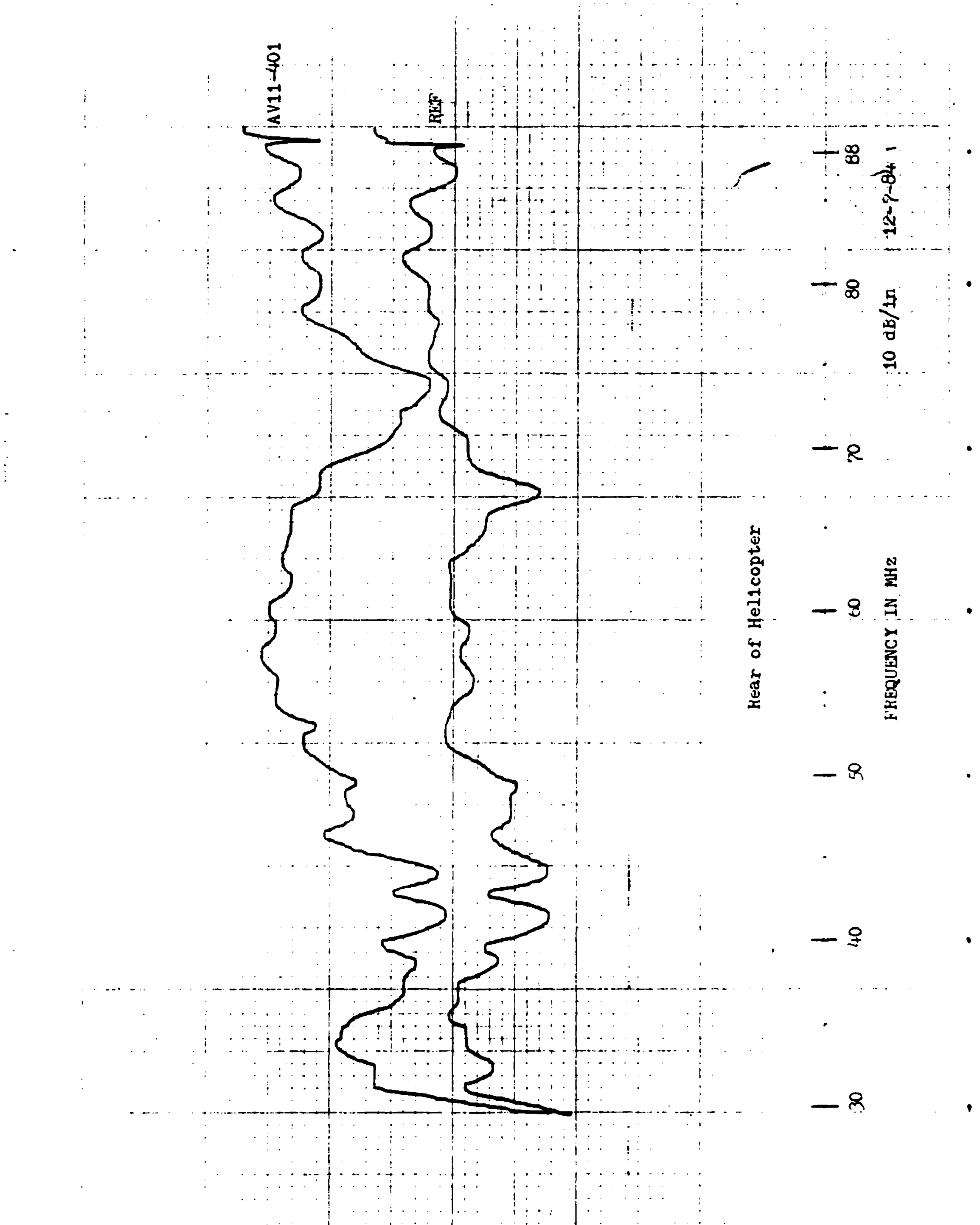

FM10-22-6
REF
12-7-84
10 db/in
88
80
70
60
50
40
30
Right Side of Helicopter
FREQUENCY IN MHz
FM10-22-6
REF

APPENDIX F. SWEPT PATTERNS FROM REAR OF HELICOPTER

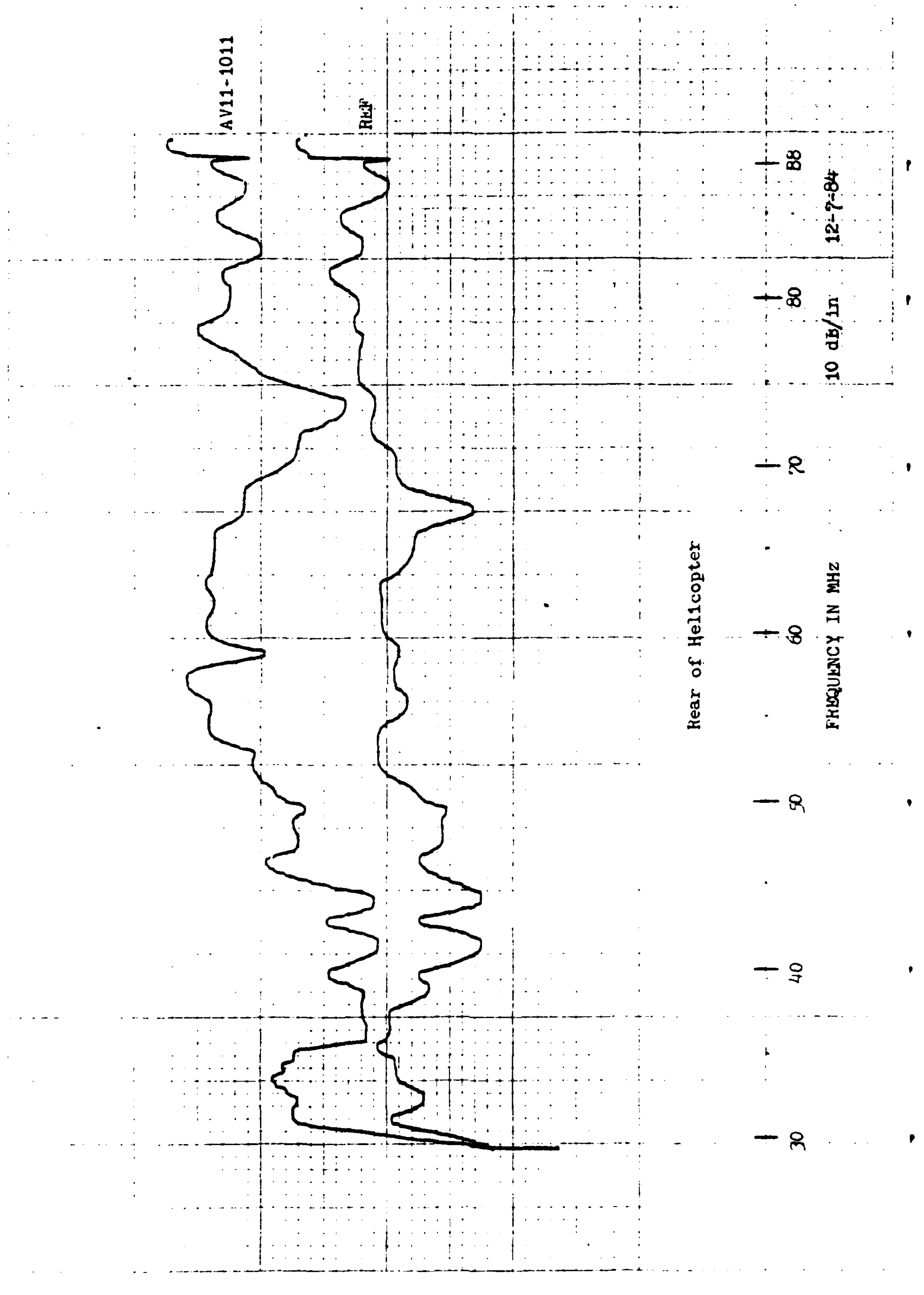


Rear of Helicopter
FREQUENCY IN MHz
10 dB/in
12-7-84
30
40
50
60
70
80
88
REF
CU-942B


REF
extraneous signal
extraneous signal
AO-1955
Rear of Helicopter
30
40
50
60
70
80
88
FREQUENCY IN MHz
10 dB/in
12-7-84



AV11-401
REF
Rear of Helicopter
FREQUENCY IN MHz
10 dB/in
12-7-84
30
40
50
60
70
80
88


AV11-1011
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80
70
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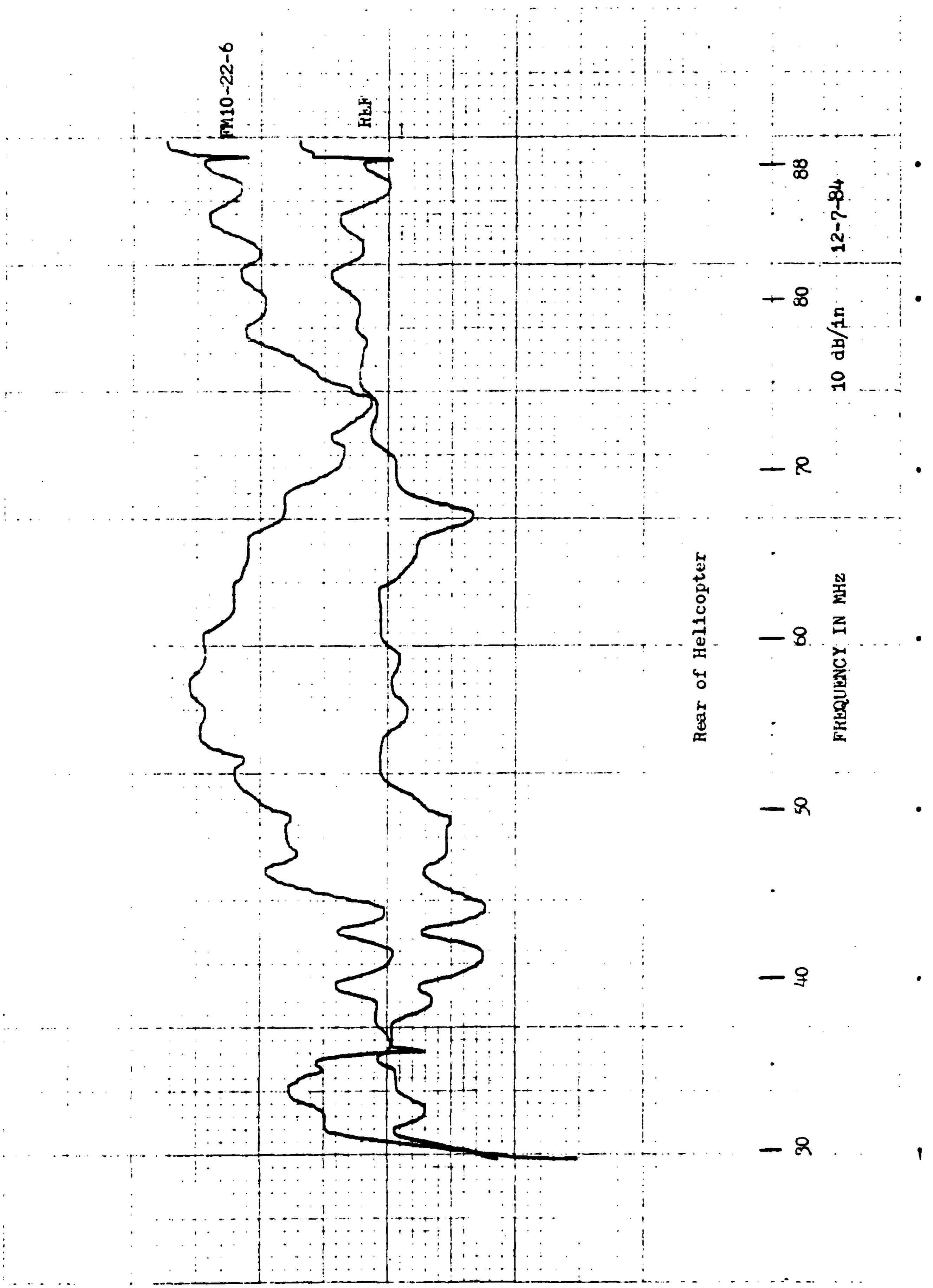
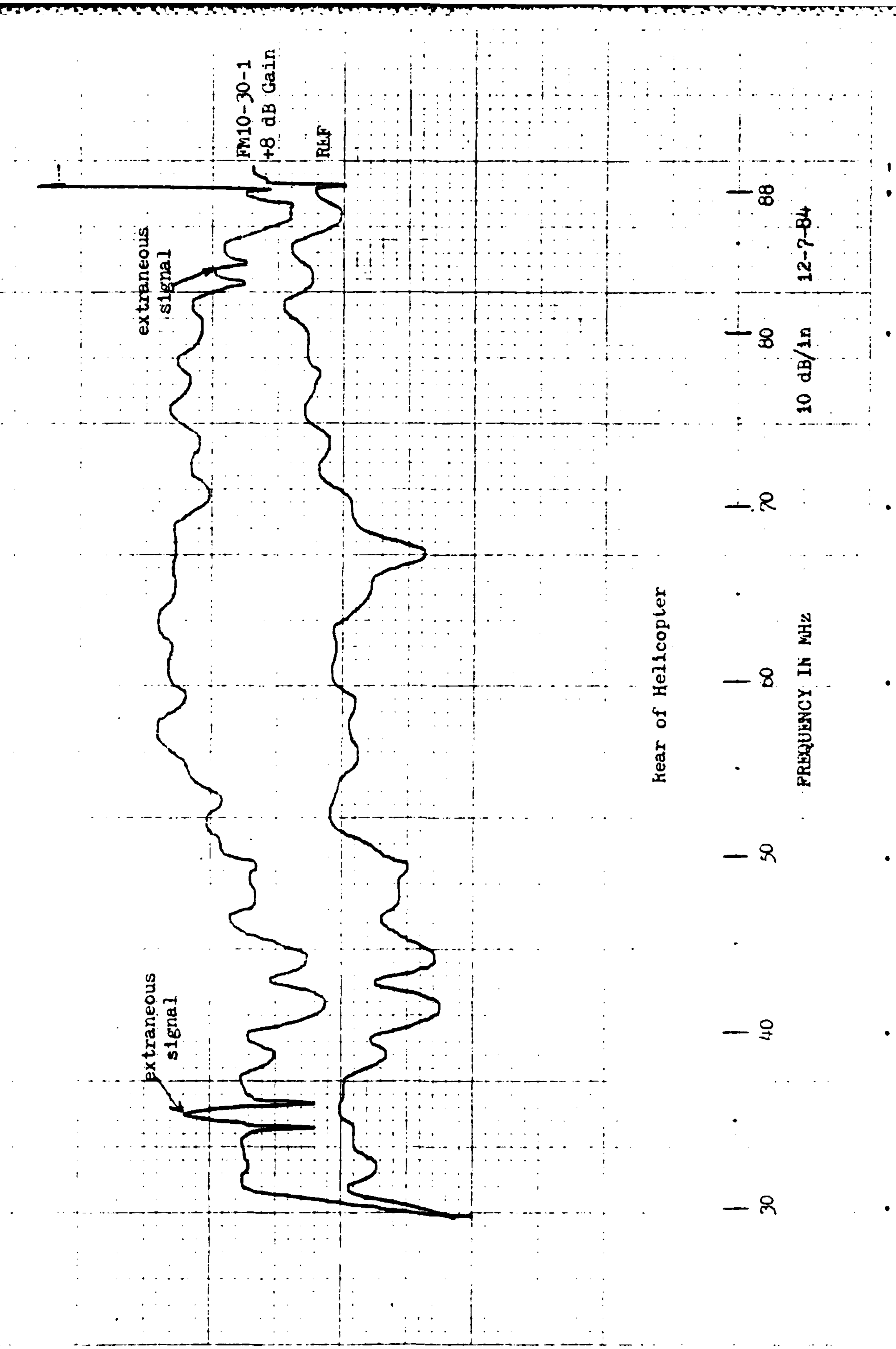
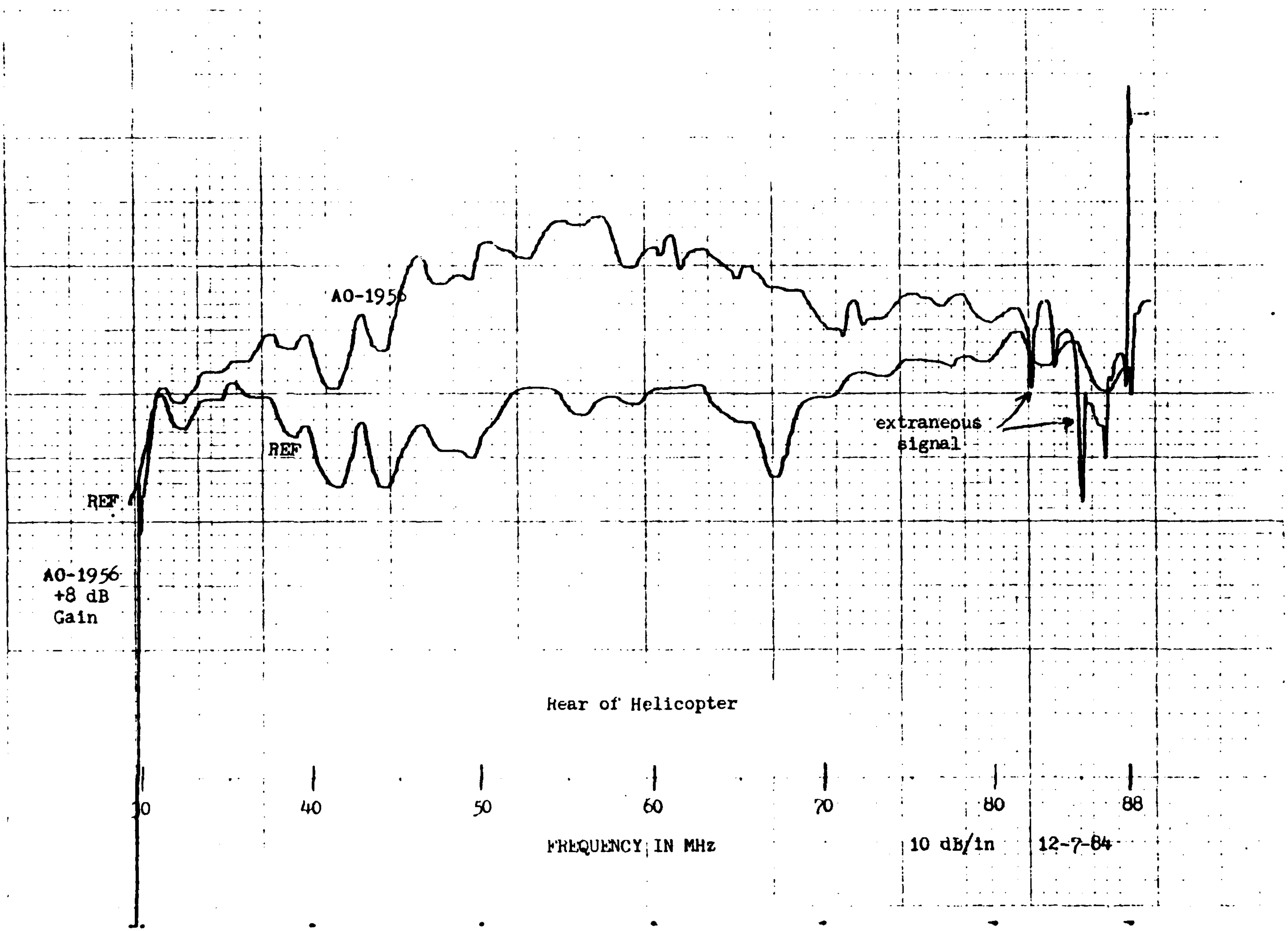
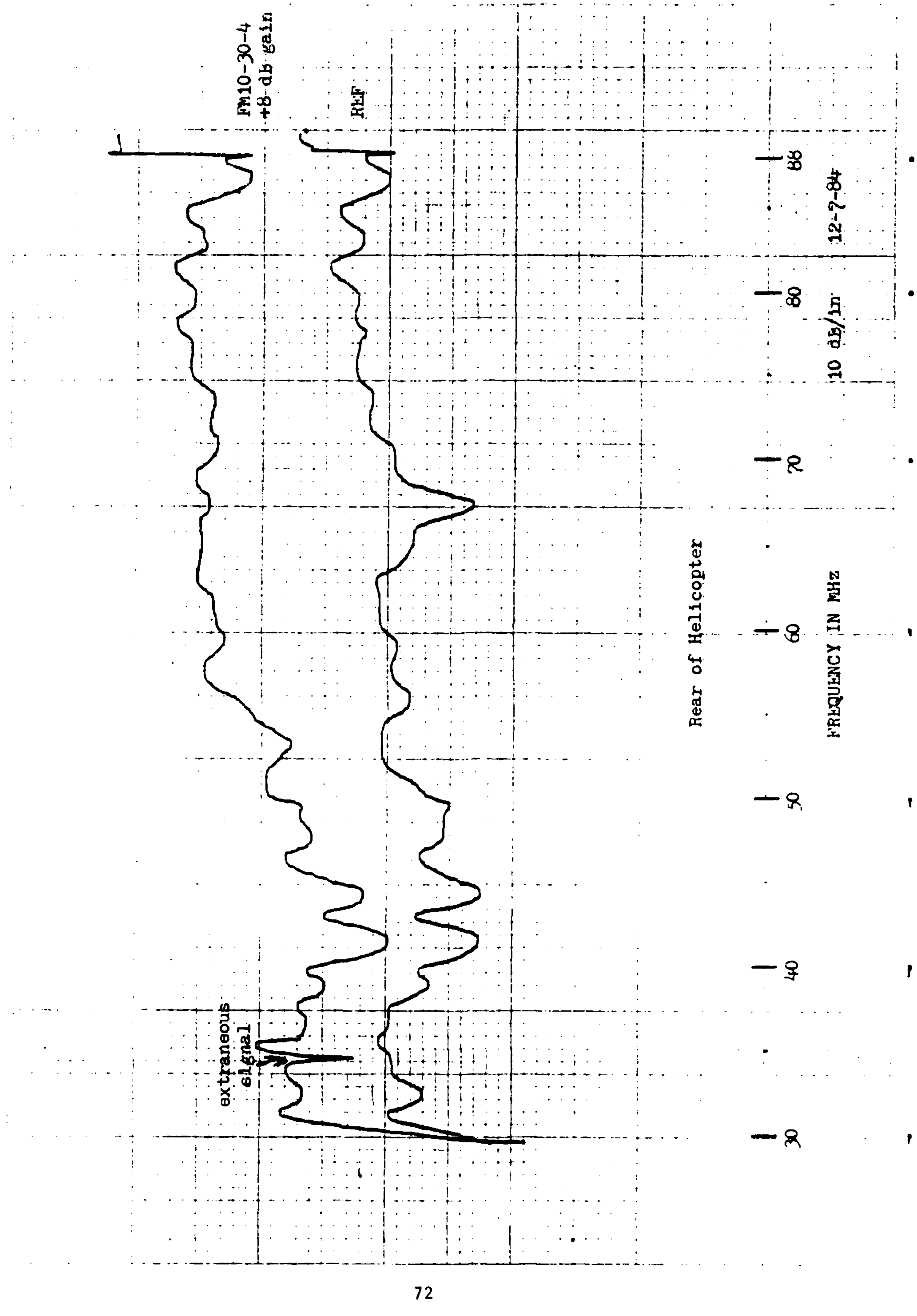
50
40
30
12-7-84
10 dB/in
Rear of Helicopter
FREQUENCY IN MHz

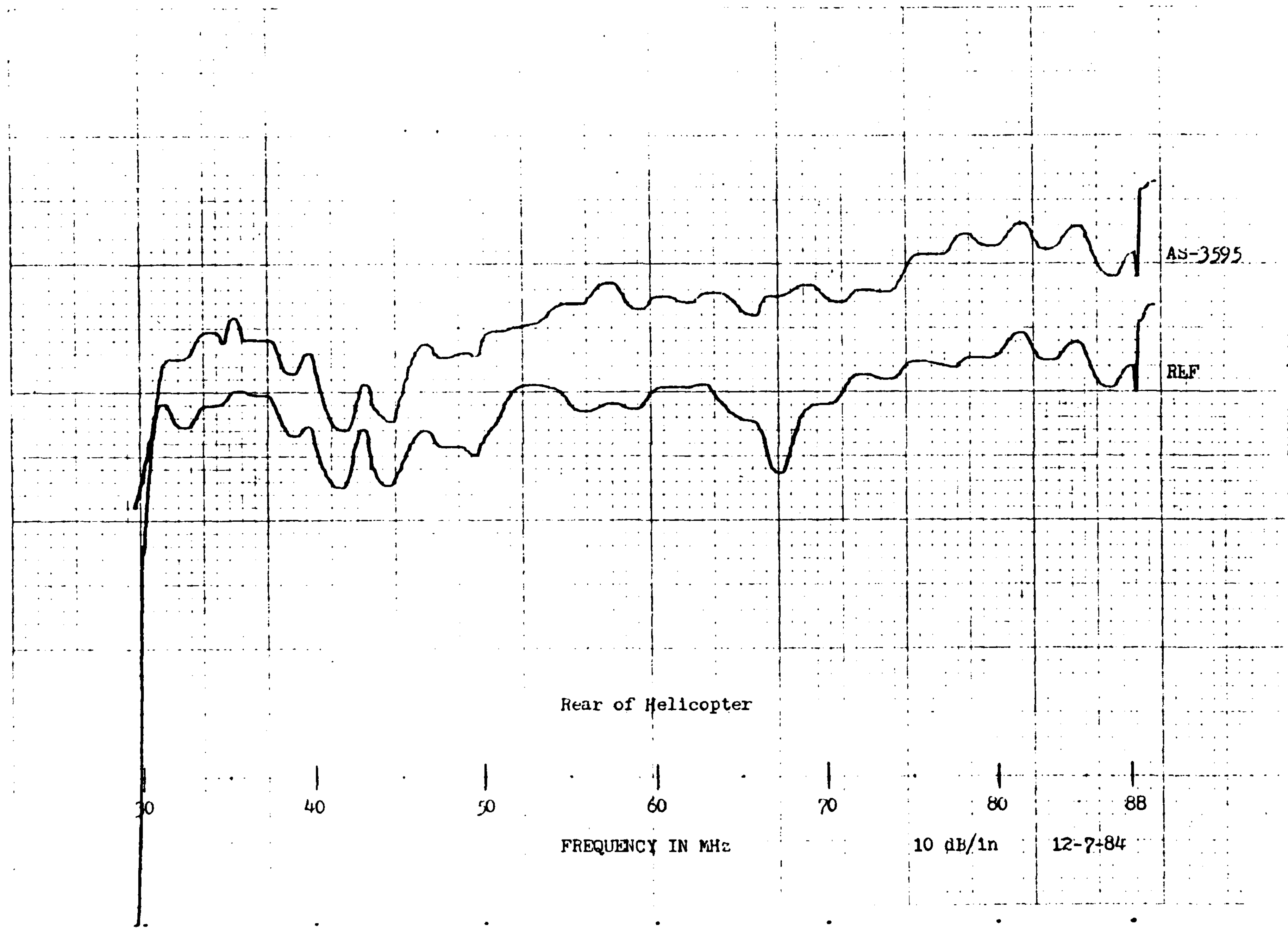


FM10-22-6
REF
88
12-7-84
80
10 dB/in
70
Rear of Helicopter
60
FREQUENCY IN MHz
50
40
30


FM10-30-1
+8 dB Gain
R&F
extraneous signal
extraneous signal
88
80
70
60
50
40
30
12-7-84
10 dB/in
Rear of Helicopter
FREQUENCY IN MHz


AO-1956
REF
REF
AO-1956
+8 dB
Gain
extraneous
signal
Rear of Helicopter
30
40
50
60
70
80
88
FREQUENCY IN MHz
10 dB/in
12-7-84


FM10-30-4
+8 db gain
REF
12-7-84
10 dB/in
88
80
70
60
50
40
30
Rear of Helicopter
FREQUENCY IN MHz
extraneous
signal


AS-3595
REF
Rear of Helicopter
30
40
50
60
70
80
88
FREQUENCY IN MHz
10 dB/in
12-7-84

APPENDIX G. DELSD-E REPORT NO. 76, 22 MARCH 1985, VIBRATION STUDY OF DAYTON-GRANGER FM 10-360 QUAD POD ANTENNA BY MICHAEL A. RALPH AND DOUGLAS E. McCOY

U. S. ARMY ELECTRONICS RESEARCH & DEVELOPMENT COMMAND

Fort Monmouth, New Jersey

ENGINEERING DIVISION
TECHNICAL SUPPORT ACTIVITY

VIBRATION SURVEY OF THE DAYTON-GRANGER
FM 10-360 QUAD POD ANTENNA

Prepared By

MICHAEL A. RALPH
DOUGLAS E. McCOY

DELSD-E REPORT NO. 76 — 22 MARCH 1985

NOTICES

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

DELSD-E REPORT NO. 76 22 March 1985

VIBRATION SURVEY OF THE DAYTON-GRANGER FM10-360 QUAD POD ANTENNA

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U.S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND
FORT MONMOUTH, NJ 07703-5301

VIBRATION SURVEY OF THE DAYTON-GRANGER FM10-360 QUAD POD ANTENNA

TABLE OF CONTENTS

MECHANICAL ENGINEERING BRANCH
ENGINEERING DIVISION
ERADCOM TECHNICAL SUPPORT ACTIVITY
FORT MONMOUTH, NJ 07703-5301

DELSD-EM 22 March 1985

DELSD-E REPORT NO. 76

SUBJECT: Vibration Survey of the Dayton-Granger FM 10-360 Quad Pod Antenna

1. BACKGROUND:

a. The Dayton-Granger FM 10-360 Quad Pod Antenna was one of several antennas being investigated for use with the SINCGARS radio set. Previous flight testing of the antenna on a CH-47 Helicopter revealed serious vibration problems due to the coupling of the antenna's resonant frequency with the helicopter forcing frequencies.

b. A stipulation in the Airworthiness Release for flight testing of the antenna on a UH-1 Helicopter was that an in-flight vibration survey of the antenna be performed and an analysis of the data provided to the Aviation Systems Command (AVSCOM) in St. Louis, MO, for study. Mr. Bernard Ricciardi of the Avionics Research and Development Activity (AVRADA) requested the survey.

2. PURPOSE:

The purpose of the vibration survey was to determine the vibration characteristics of the FM 10-360 antenna on a UH-1H helicopter.

3. TEST SITE AND DATE:

The inflight vibration survey was performed on a UH-1H Helicopter, Serial Number 21684, by TSA personnel at the ERADCOM Flight Test Activity (EFTA), Lakehurst, NJ, on 9 August 1984.

4. TEST EQUIPMENT AND PROCEDURE:

a. The flight survey was performed using Endevco Model 2227 Single Axis Accelerometers and an Endevco Model 2223C Triaxial Accelerometer. Output from the accelerometers was passed through voltage amplifiers and then fed into a Bell & Howell MARS 2000LT Modular Airborne Recording System. The recording system uses intermediate band one inch magnetic tape and can record up to 14 channels of information. The recording system and amplifiers were palletized and installed in the cargo area (Figure 1). All instrumentation was calibrated prior to use.

b. Single axis accelerometers were secured, using epoxy, at the top of each of the four (4) vertical support members. These recorded output in the y direction, i.e., side to side. Another single axis accelerometer was mounted on the horizontal element to record output in the x direction, i.e., fore and aft. The triaxial accelerometer was mounted on the base of the antenna near the aircraft skin to measure the input levels (Figures 2 and 3).

c. The helicopter was flown in a broad flight profile to simulate actual mission use. The profile was as follows: ground runup, taxi and takeoff, level flight at 70-80 knots, level flight at 90-95 knots, level flight at 105-110 knots, 45 degrees banked left (counterclockwise) turn, 45 degrees banked right (clockwise) turn, out of ground effect (OGE) hover, low level flight, in ground effect (IGE) hover, landing, and engine shutdown.

5. DISCUSSION:

a. The most significant sources of vibration in a UH-1H Helicopter are due to the main rotor and the tail rotor. The forcing frequencies are shown in Table 1.

Table 1. UH-1H Vibration Forcing Frequencies

SOURCE		FORCING FREQUENCY (Hz)
MAIN ROTOR	Fundamental	5.4
	1st Blade Passage	10.8
	2nd Blade Passage	21.6
	3rd Blade Passage	32.4
	4th Blade Passage	43.2
	5th Blade Passage	54.0
	6th Blade Passage	64.8
	7th Blade Passage	75.6
TAIL ROTOR	Fundamental	27.6
	1st Blade Passage	55.2
	2nd Blade Passage	110.4
	3rd Blade Passage	165.6
	4th Blade Passage	220.8
	5th Blade Passage	276.0

As the forcing frequency increases, the energy level decreases. The forcing frequency is determined by multiplying the rotor RPM, which for the main rotor is 324, by the number of blades, two (2), and dividing by 60.

b. The FM10-360 antenna was installed in place of the existing FM10-30 antenna on the helicopter roof (Figure 4). The flight survey was performed to measure the actual vibration frequencies and levels experienced by the antenna. The output of the antenna should not show amplification of the input forcing frequency levels throughout the entire flight profile. Any consistent amplification greater than two (2) will indicate that one of the resonant frequencies is very close to or the same as one of the forcing frequencies. Consistently high amplification could cause the antenna to fail or could cause the supporting aircraft structure to fail, as was the case on the CH-47 Helicopter.

c. The results of the flight survey were plotted and the amplification factors calculated. A modal analysis of the antenna was also performed. The modal analysis, which uses the impulse hammer excitation method, was performed with the antenna installed on the helicopter, and with the antenna mounted on a fixture in the laboratory. The modal analysis was used to verify the actual antenna natural resonant frequencies.

6. RESULTS:

a. The results of the modal analysis are presented in Figures 5 thru 9. The illustrations present the mode shape, and the corresponding frequency is shown in the upper right hand corner. A comparison of the resonant frequencies of the antenna with the helicopter forcing frequencies reveals two problems: one at the resonant frequency of 21.1 Hz (21.6 Hz forcing frequency), and the other at 32.5 Hz (32.4 Hz forcing frequency).

b. The results of the flight survey are presented in Figures 10 thru 41. Figures 10 thru 20 present the output measured by accelerometer #12, and the helicopter input measured in the y direction by accelerometer #3. Figures 21 thru 31 present the output measured by accelerometer #8, and the helicopter input measured in the z direction by accelerometer #5. Figures 32 thru 41 present the x direction helicopter input measured by accelerometer #6. The data in the graphs is an average of all data taken during the particular flight maneuver listed. Accelerometers 8 and 12 were identified in modal analysis as being in locations that would reveal significant amplification. The other accelerometers measured similar data.

c. The input data are the helicopter forcing frequencies at the associated g levels. The output from the antenna is its response to these inputs. A comparison of the maximum input level at each forcing frequency during each flight maneuver to the maximum antenna output reveals extreme amplification at the identified resonant frequencies of 21.1 Hz and 32.5 Hz throughout the entire flight profile. These comparisons are presented in Figure 42.

7. CONCLUSION:

The results show that amplification factors much greater than two exist throughout the flight profile for the FM 10-360 Antenna. This indicates that the antenna could fail or could cause the aircraft structure to fail during prolonged flight use. The FM 10-360 Antenna as tested is unsafe for any type of inflight service on the UH-1H Helicopter.

8. RECOMMENDATION:

The FM 10-360 Antenna should not be flown on the UH-1H Helicopter, or any other helicopter with forcing frequencies similar to the UH-1H, until a redesign of the antenna and subsequent testing indicates safer vibration characteristics.

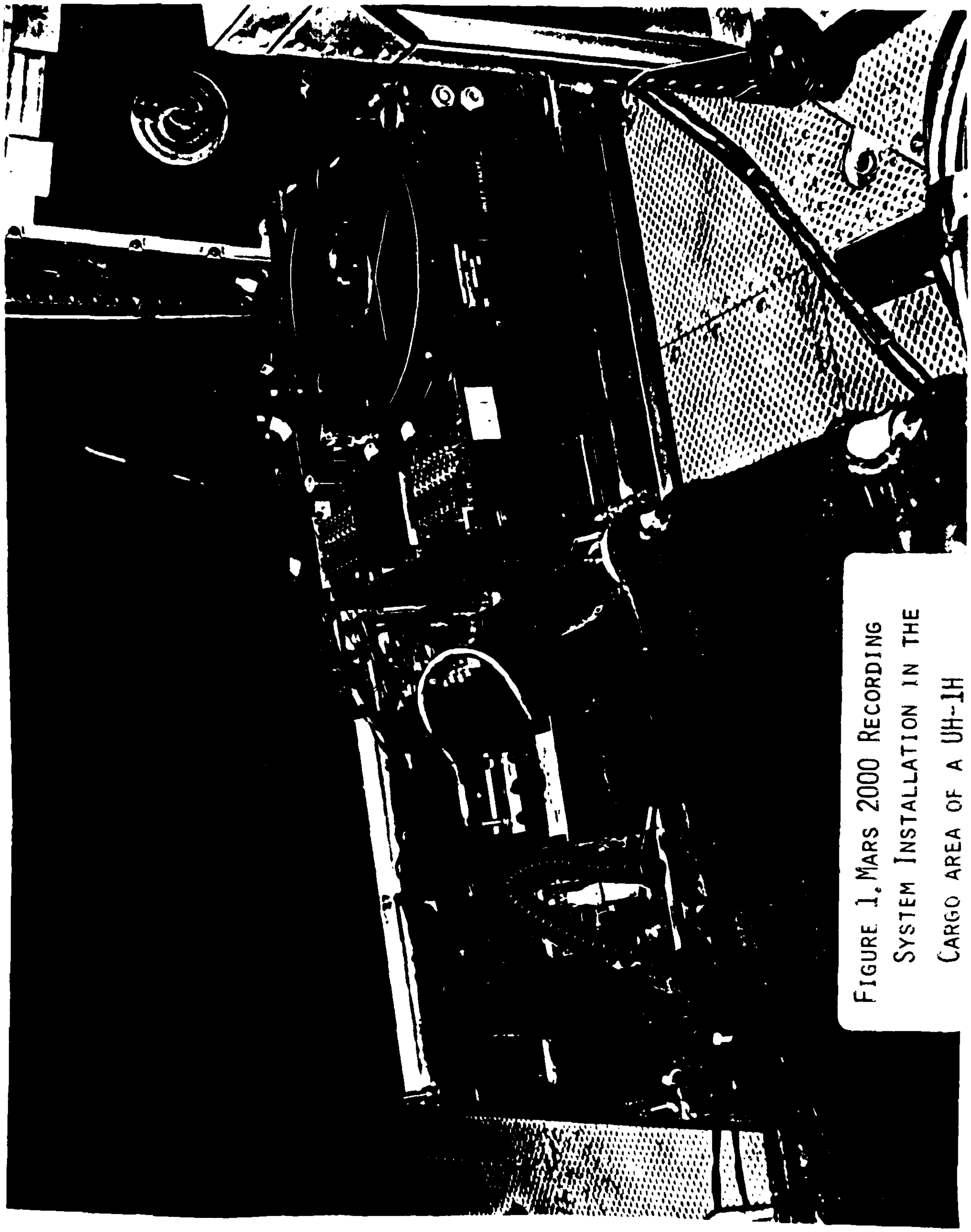


FIGURE 1. MARS 2000 RECORDING SYSTEM INSTALLATION IN THE CARGO AREA OF A UH-1H

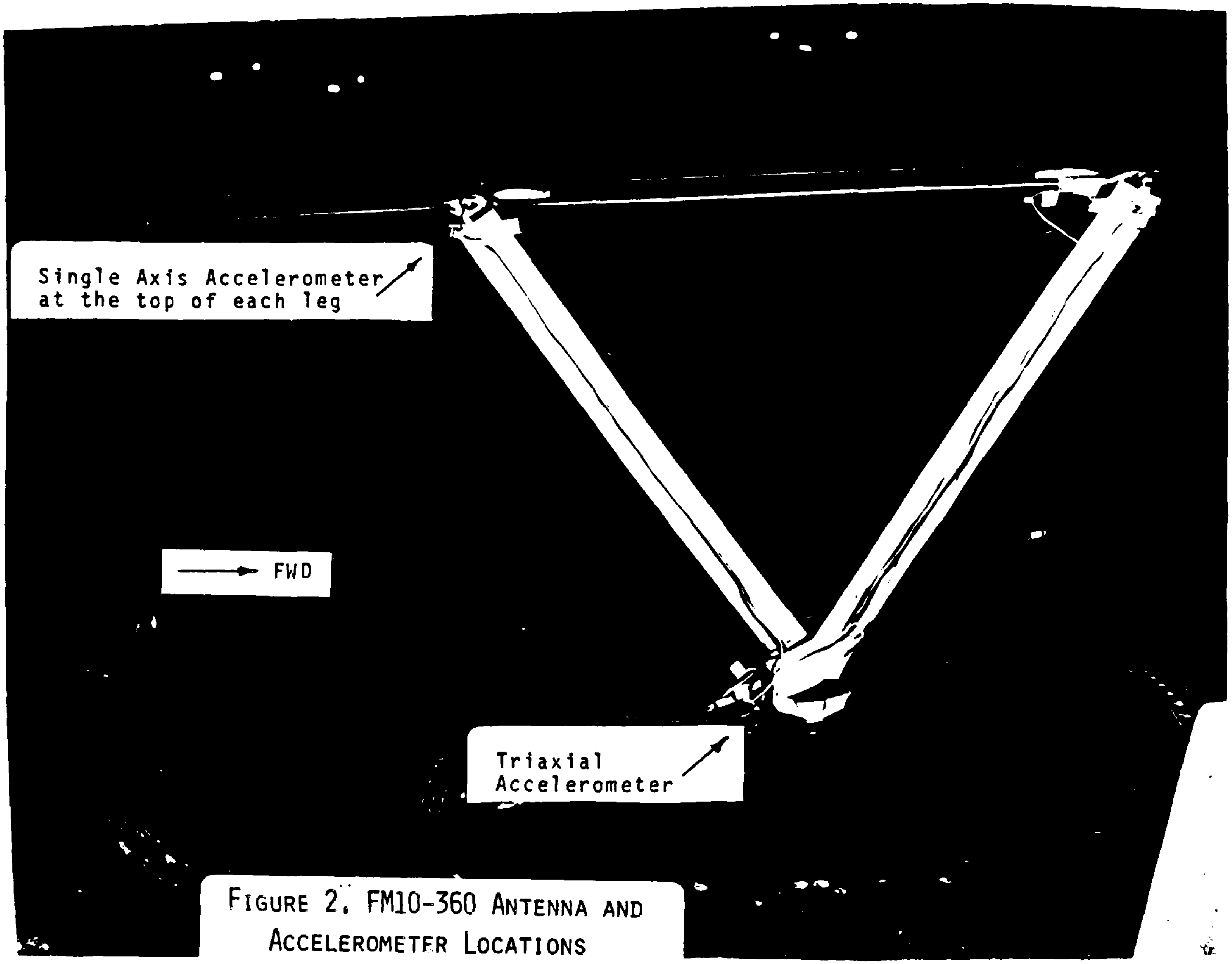


FIGURE 2. FM10-360 ANTENNA AND ACCELEROMETER LOCATIONS

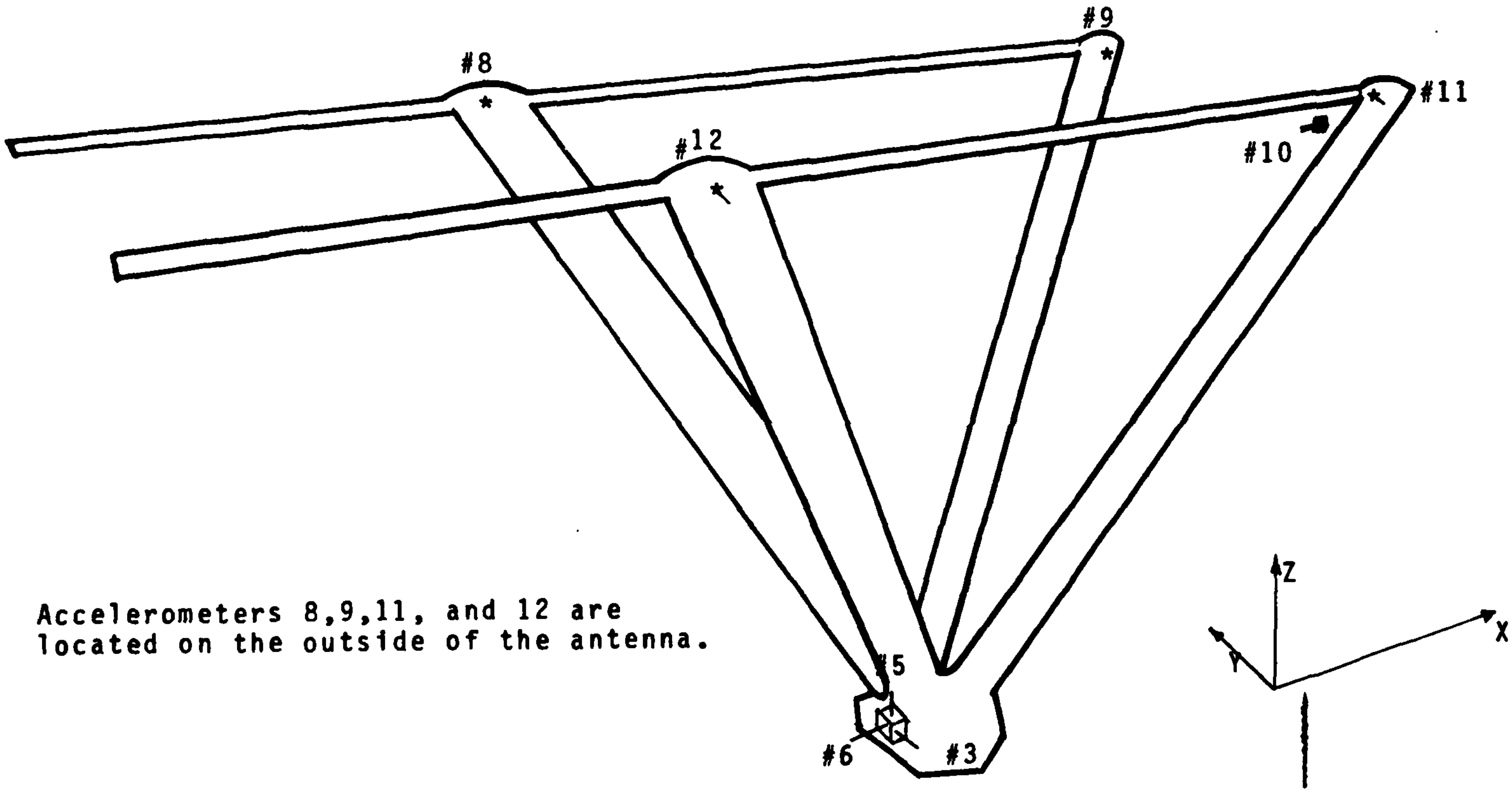


FIGURE 3. ACCELEROMETER LOCATIONS AND IDENTIFICATION NUMBERS

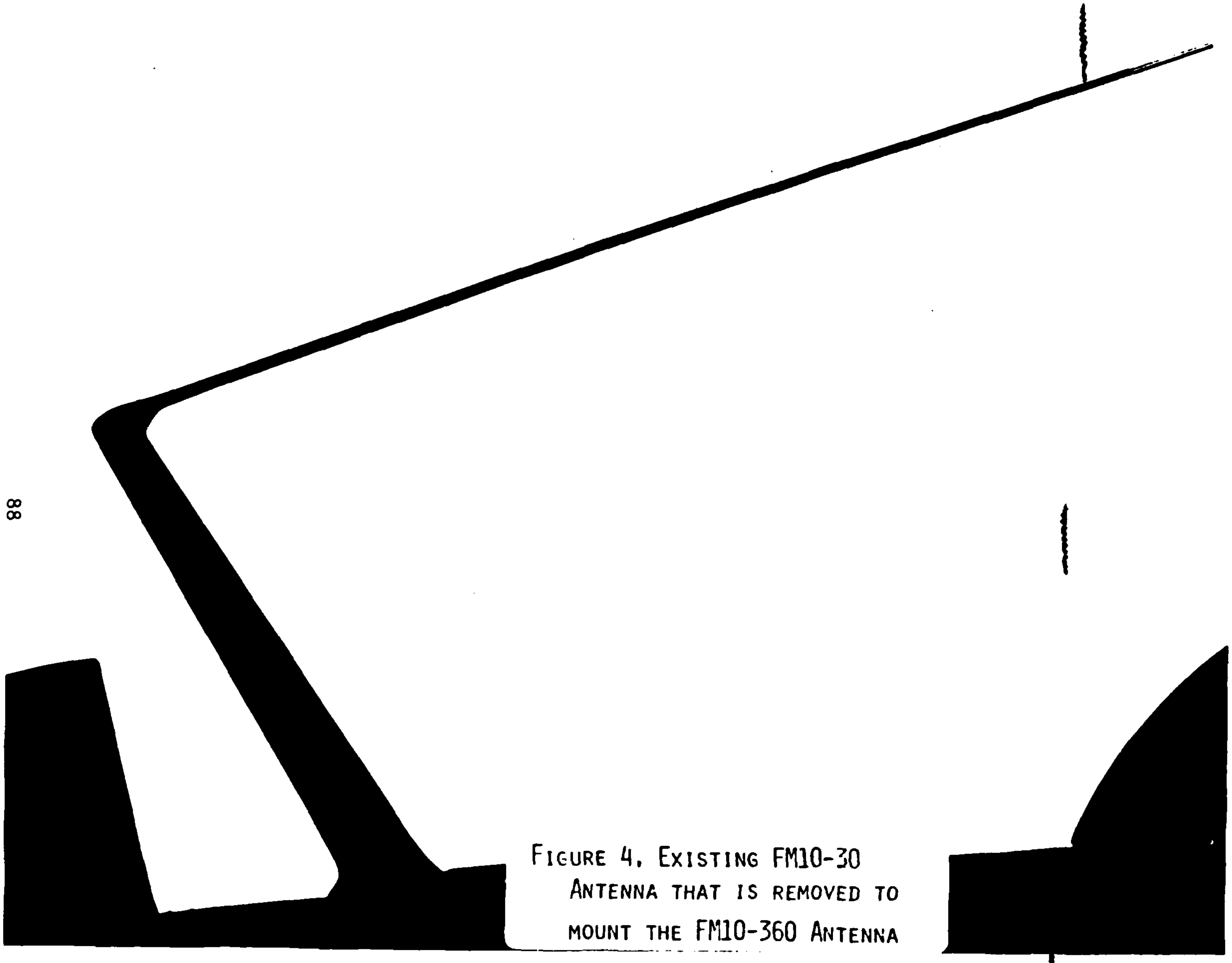


Figure 4. Existing FM10-30 Antenna that is removed to mount the FM10-360 Antenna

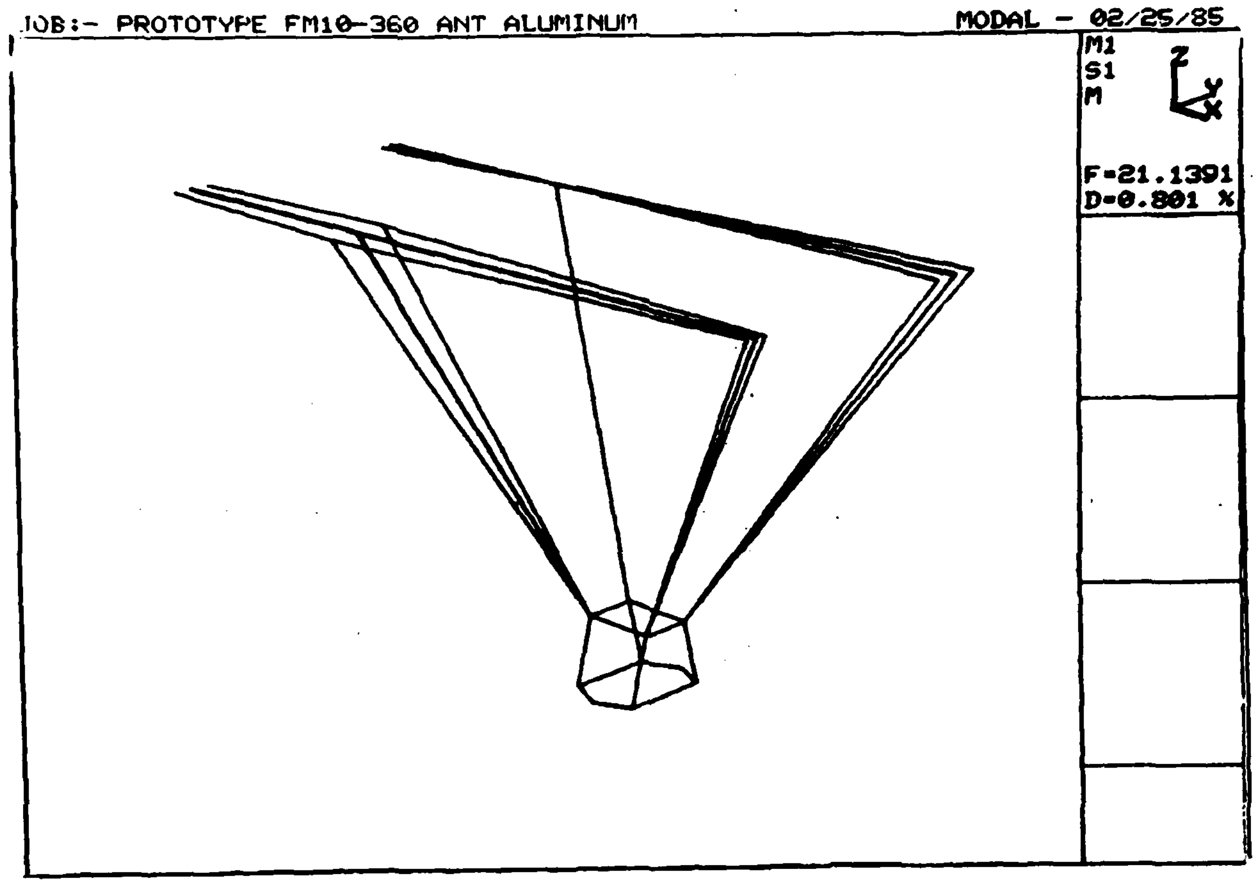


Figure 5. FM10-360 Antenna, First Mode of Vibration

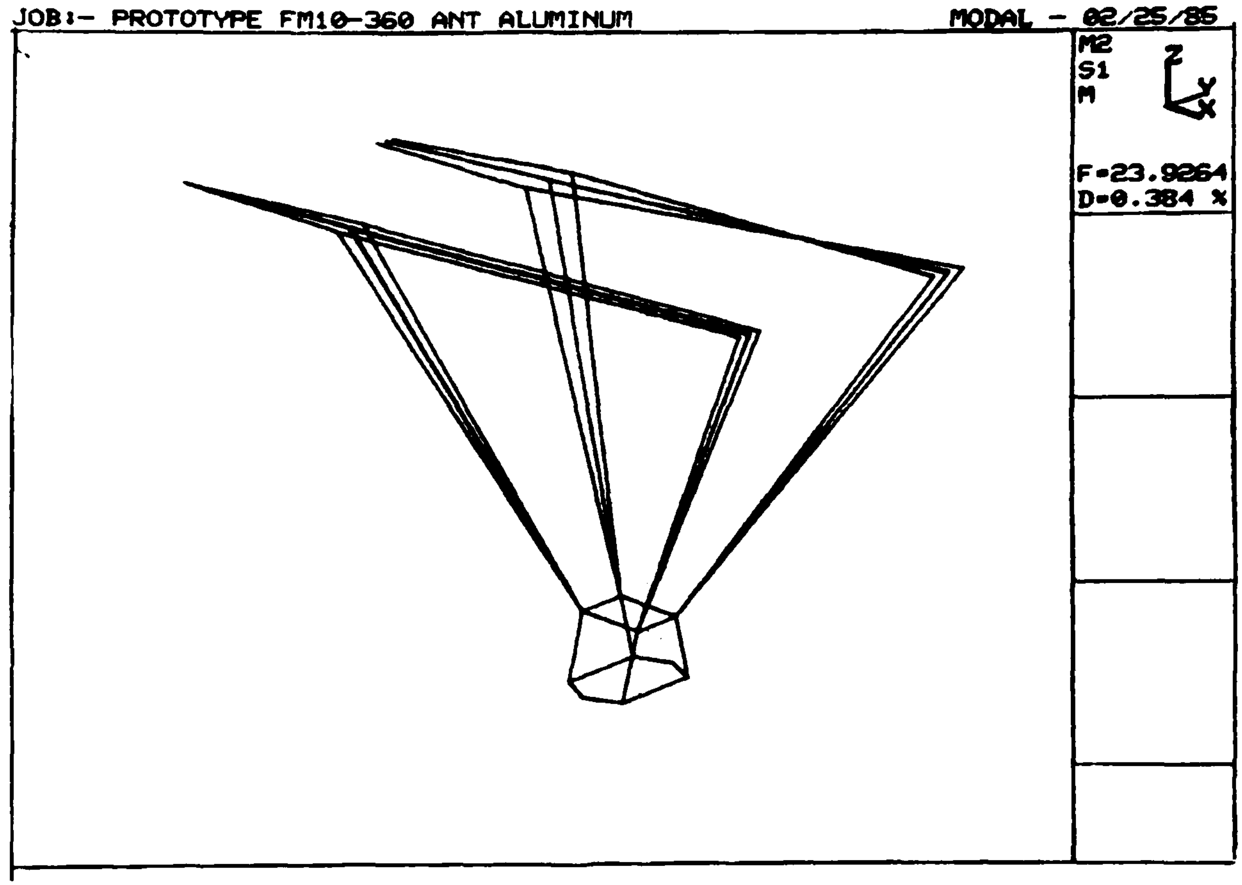


FIGURE 6. FM10-360 ANTENNA, SECOND MODE OF VIBRATION

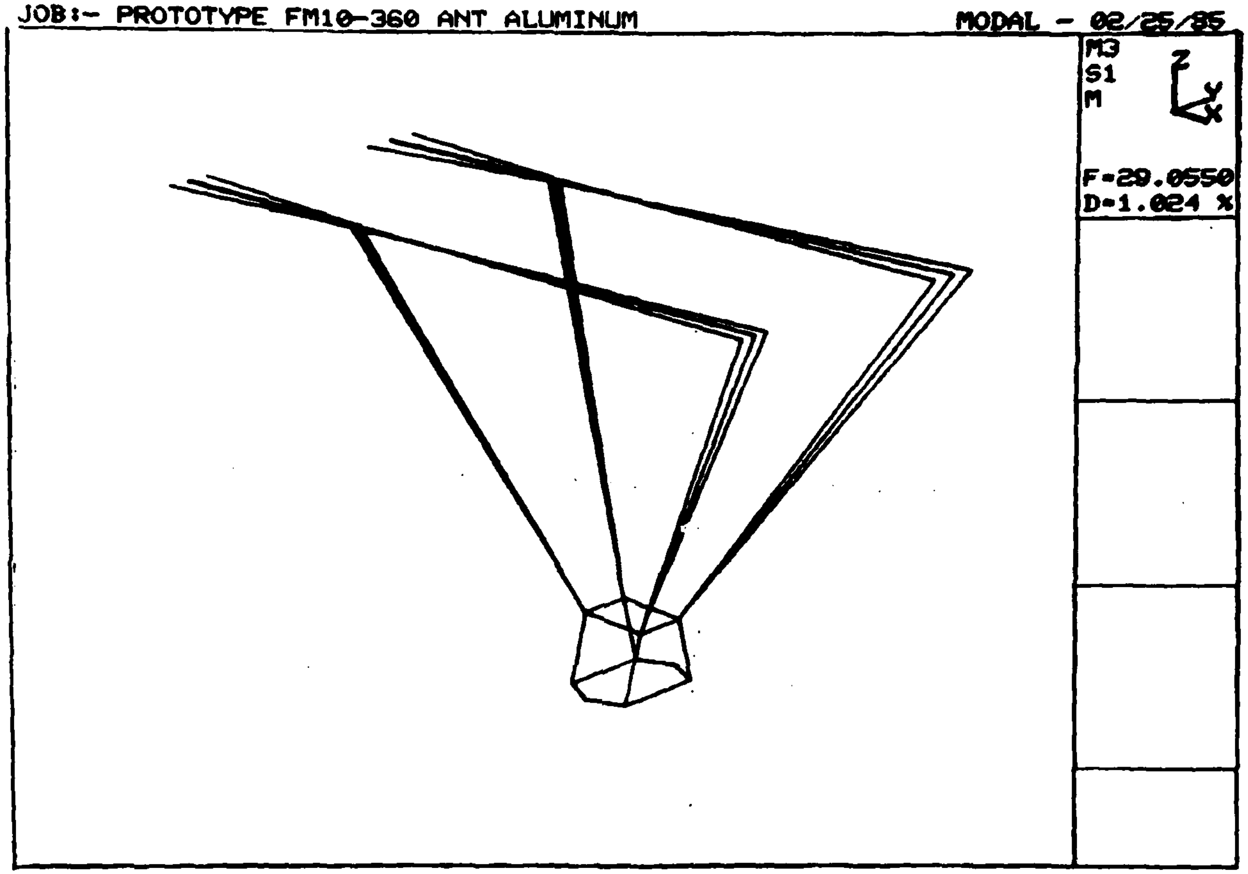


FIGURE 7. FM10-360 ANTENNA, THIRD MODE OF VIBRATION

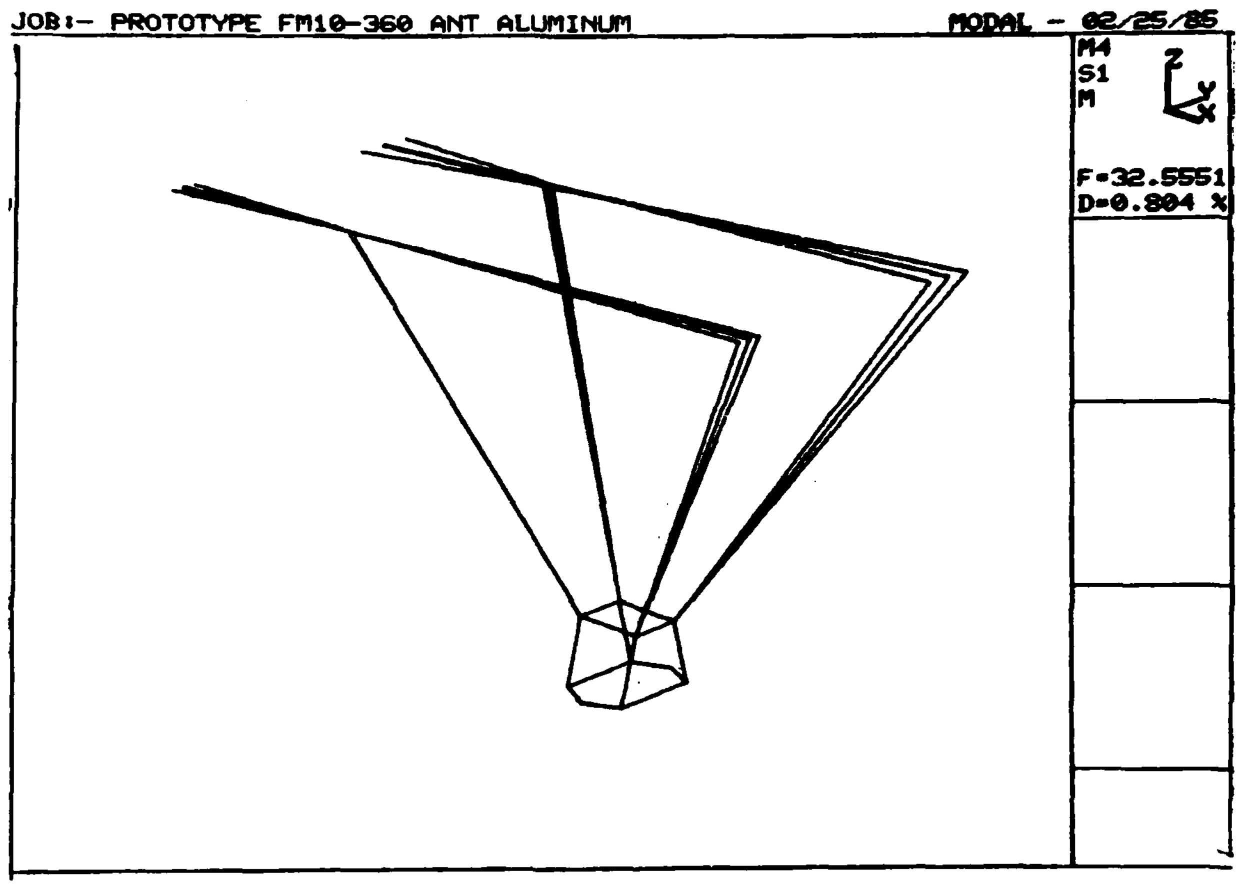


FIGURE 8. FM10-360 ANTENNA, FOURTH MODE OF VIBRATION

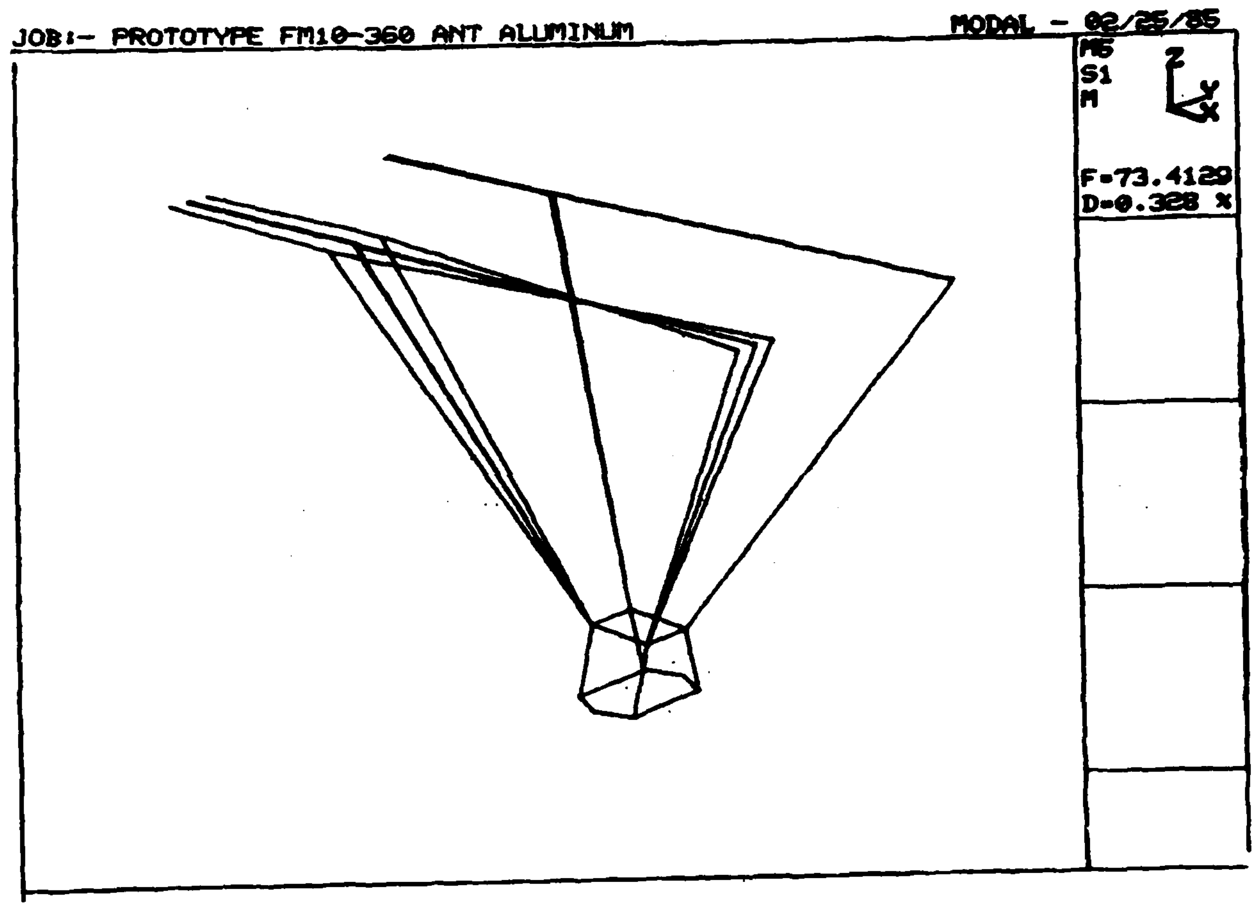


FIGURE 9. FM10-360 ANTENNA, FIFTH MODE OF VIBRATION

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

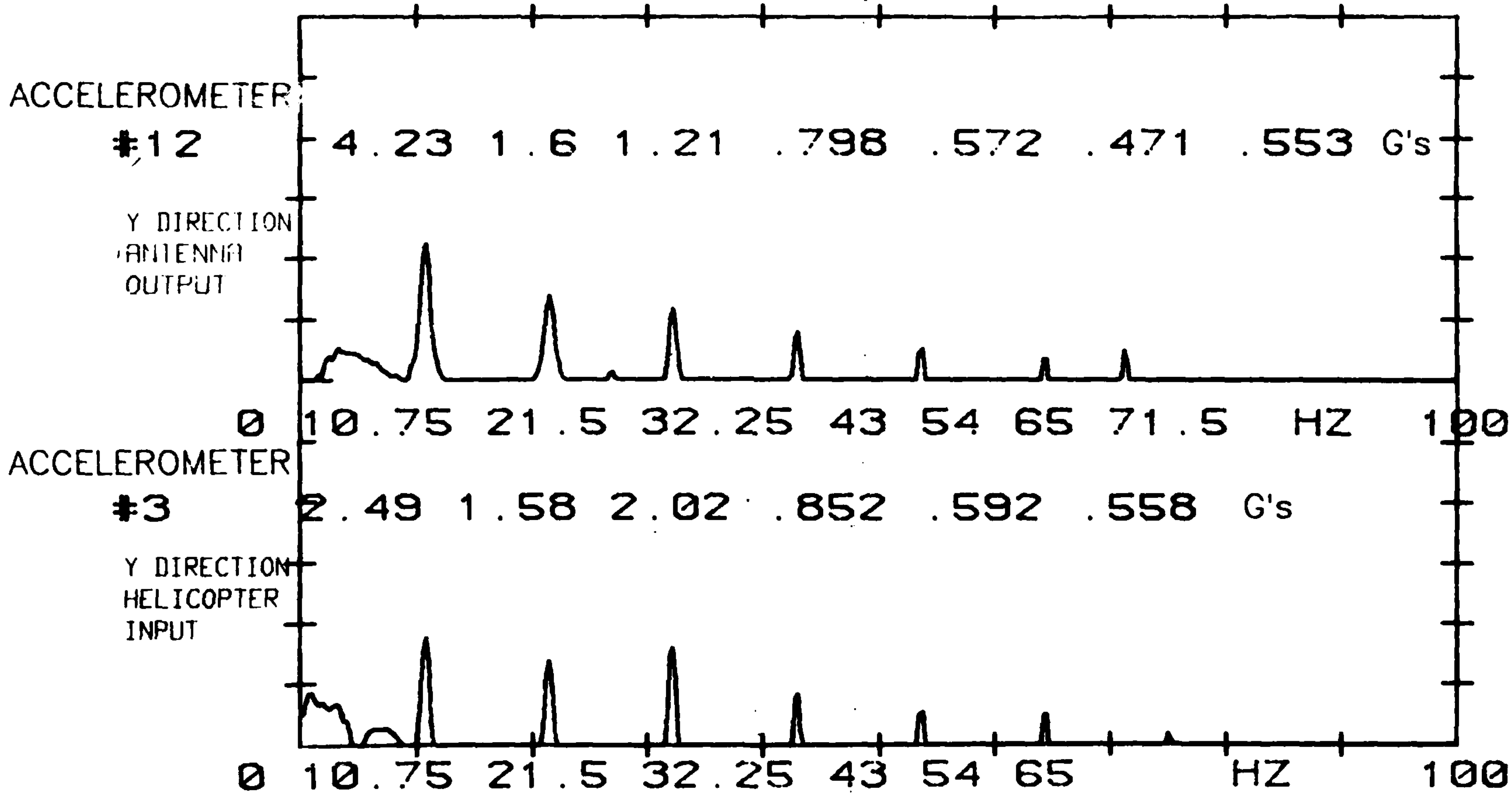


FIGURE 10. GROUND RUNUP 324 RPM: ACCELEROMETERS 3 AND 12

FM10-360 ANTENNA VIBRATION SURVEY ON UH-1H HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

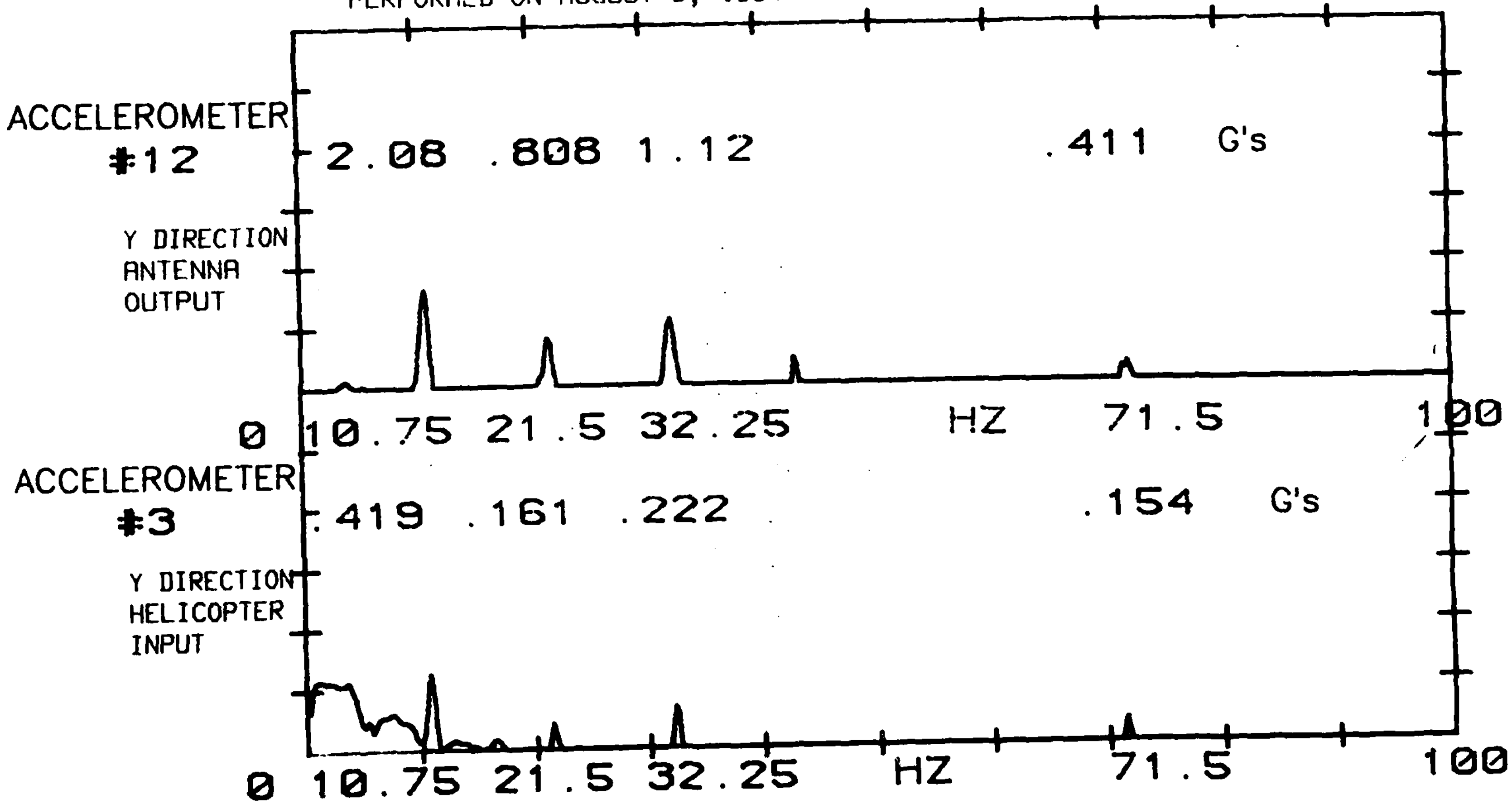


FIGURE 11. TAXI AND TAKEOFF: ACCELEROMETERS 3 AND 12

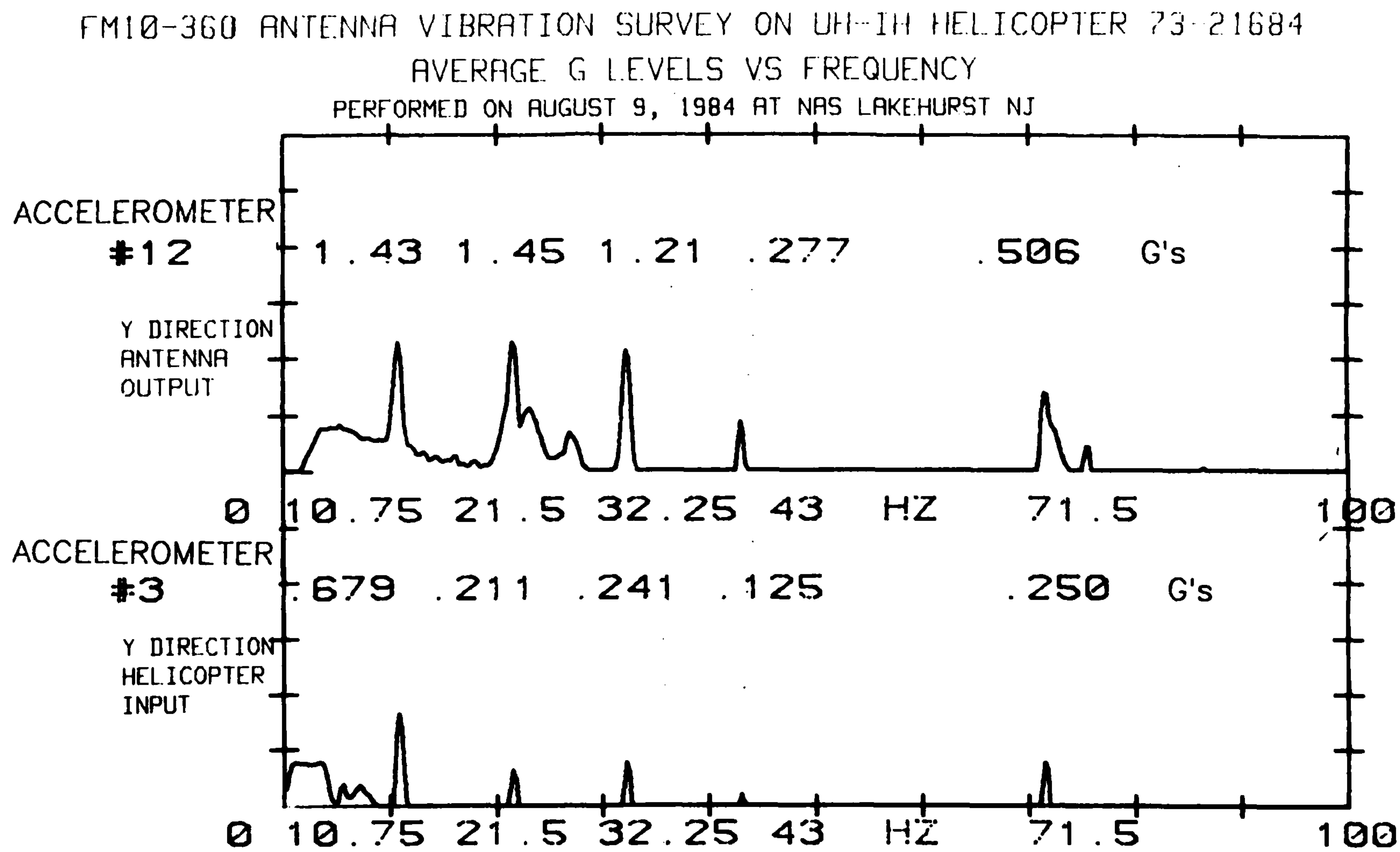


FIGURE 12. LEVEL FLIGHT 70-80 KNOTS, 100-3000 FT: ACCELEROMETERS 3 AND 12

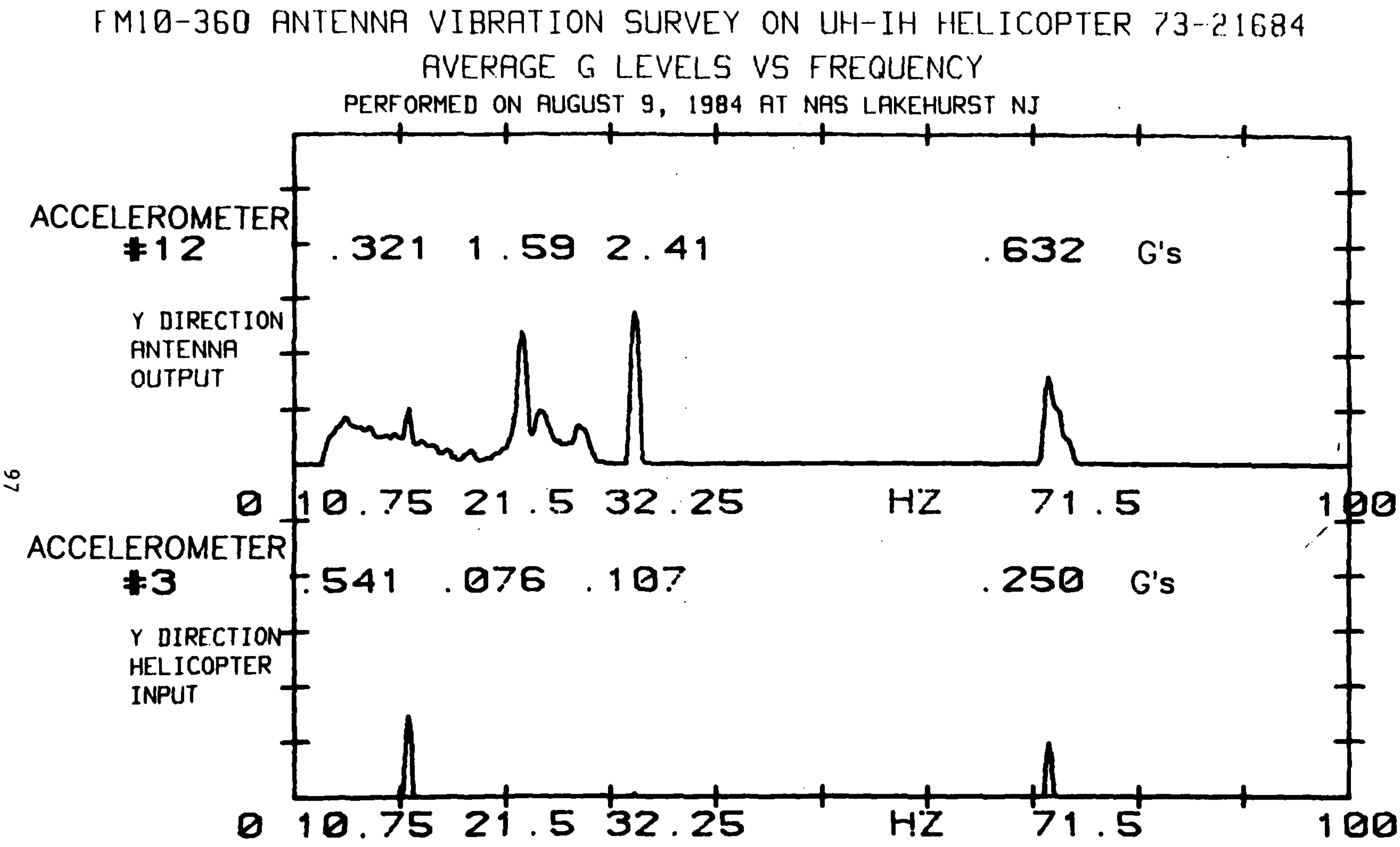


FIGURE 13. LEVEL FLIGHT 90-95 KNOTS, 3000 FT: ACCELEROMETERS 3 AND 12

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

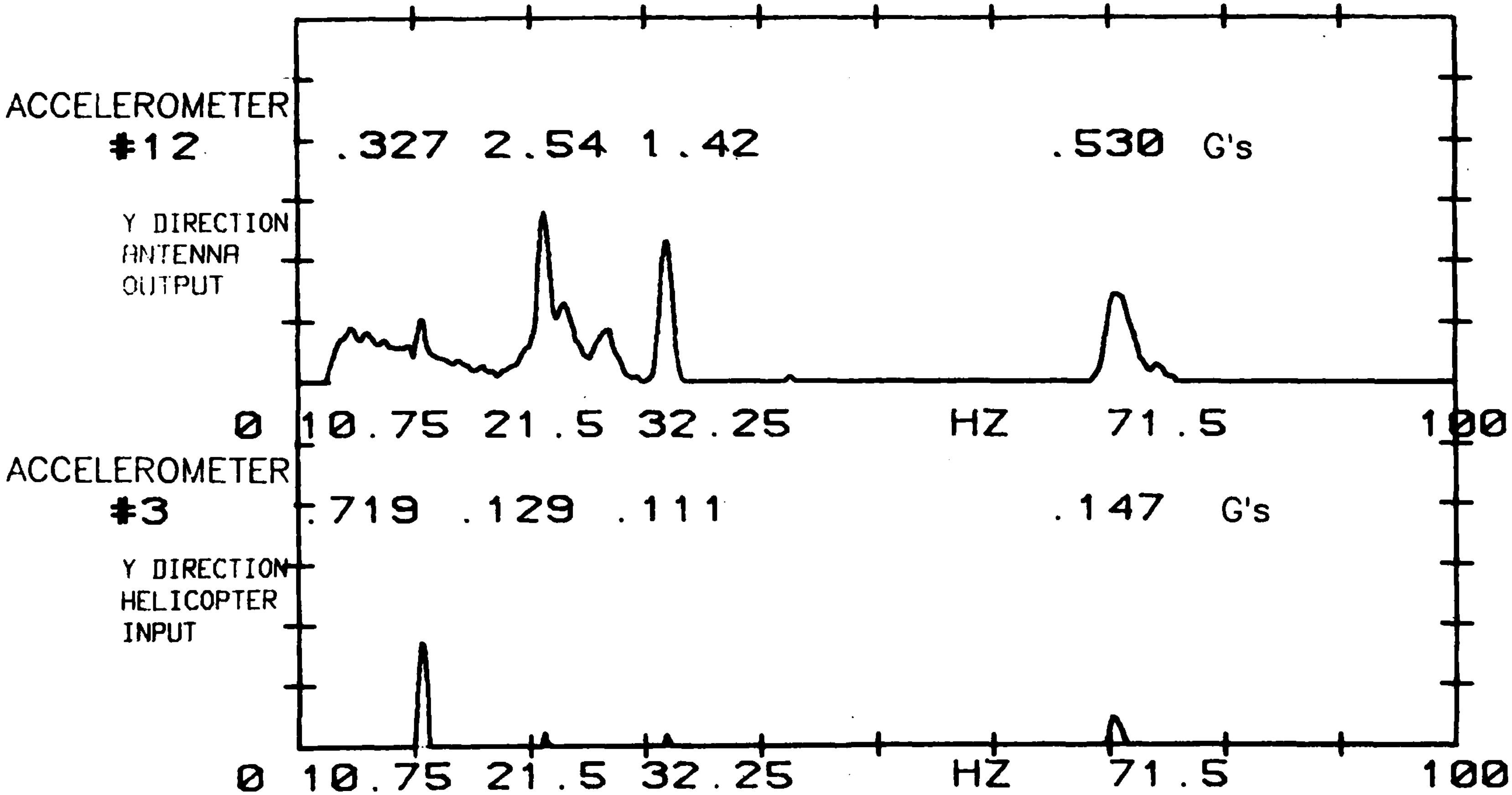


FIGURE 14. LEVEL FLIGHT 105-110 KNOTS, 3000 FT: ACCELEROMETERS 3 AND 12

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

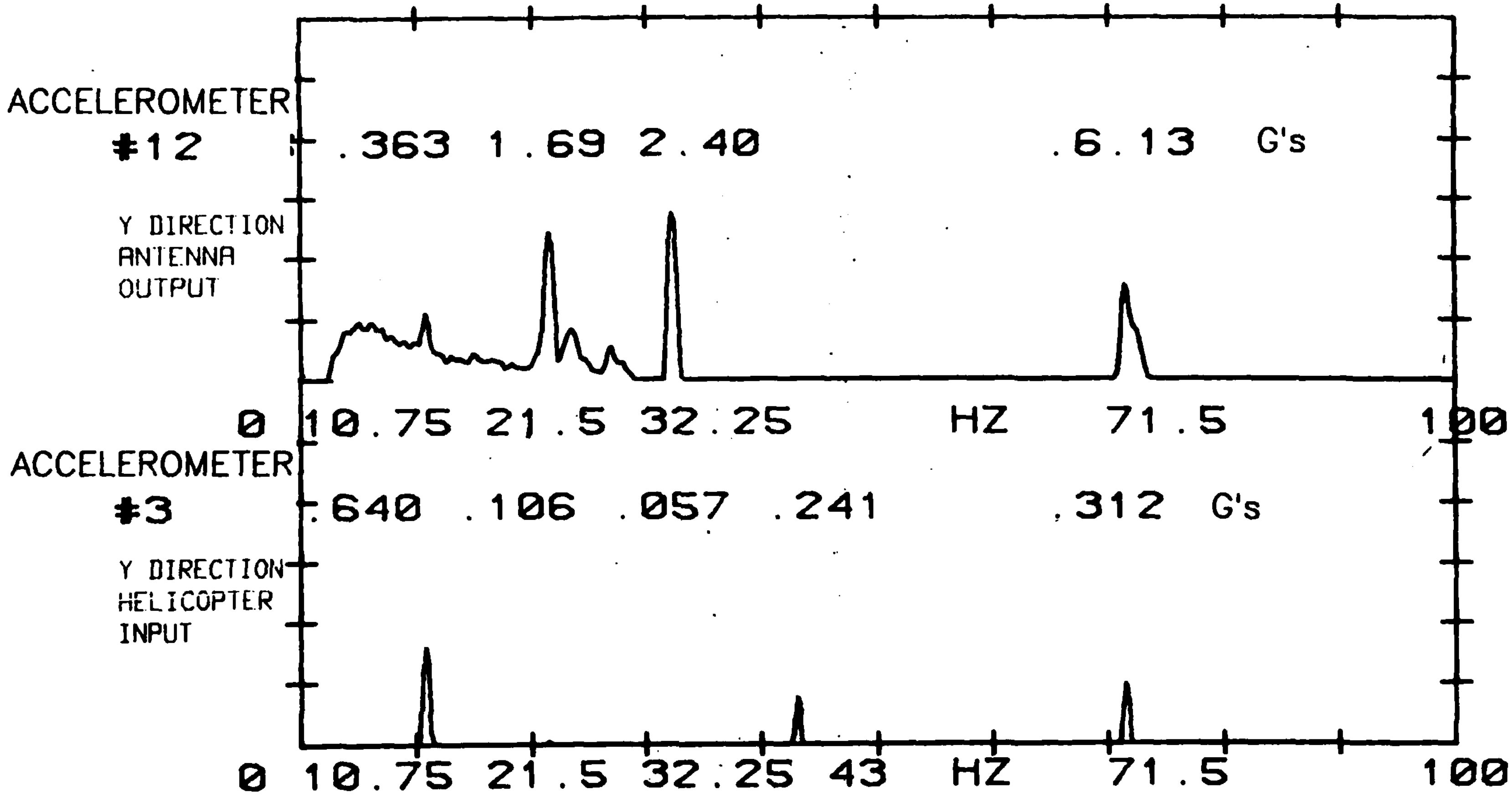


FIGURE 15. 45 LEFT BANK 70-75 KNOTS, 2800 FT: ACCELEROMETERS 3 AND 12

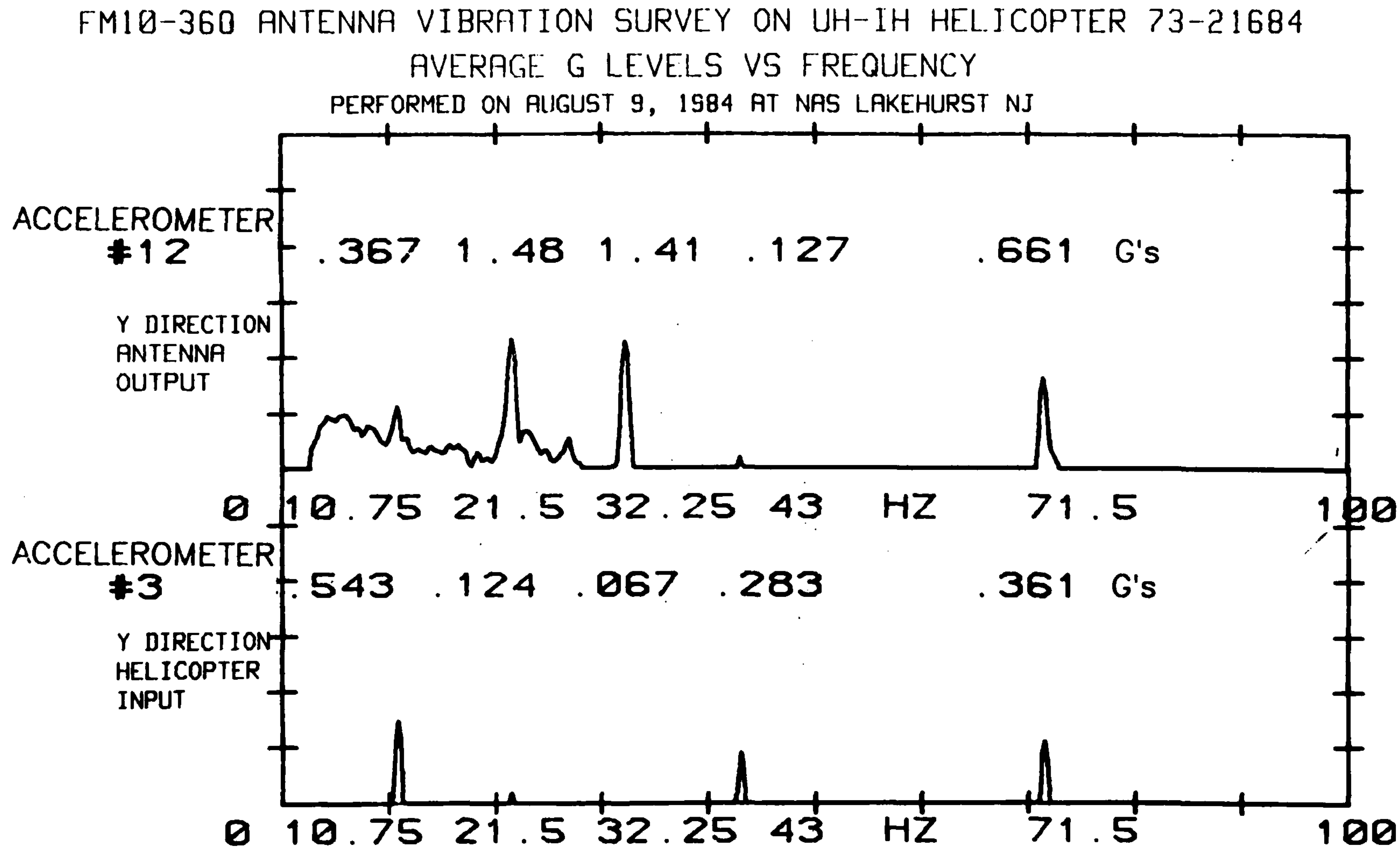


FIGURE 16. 45 RIGHT BANK 70-75 KNOTS, 2800 FT: ACCELEROMETERS 3 AND 12

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

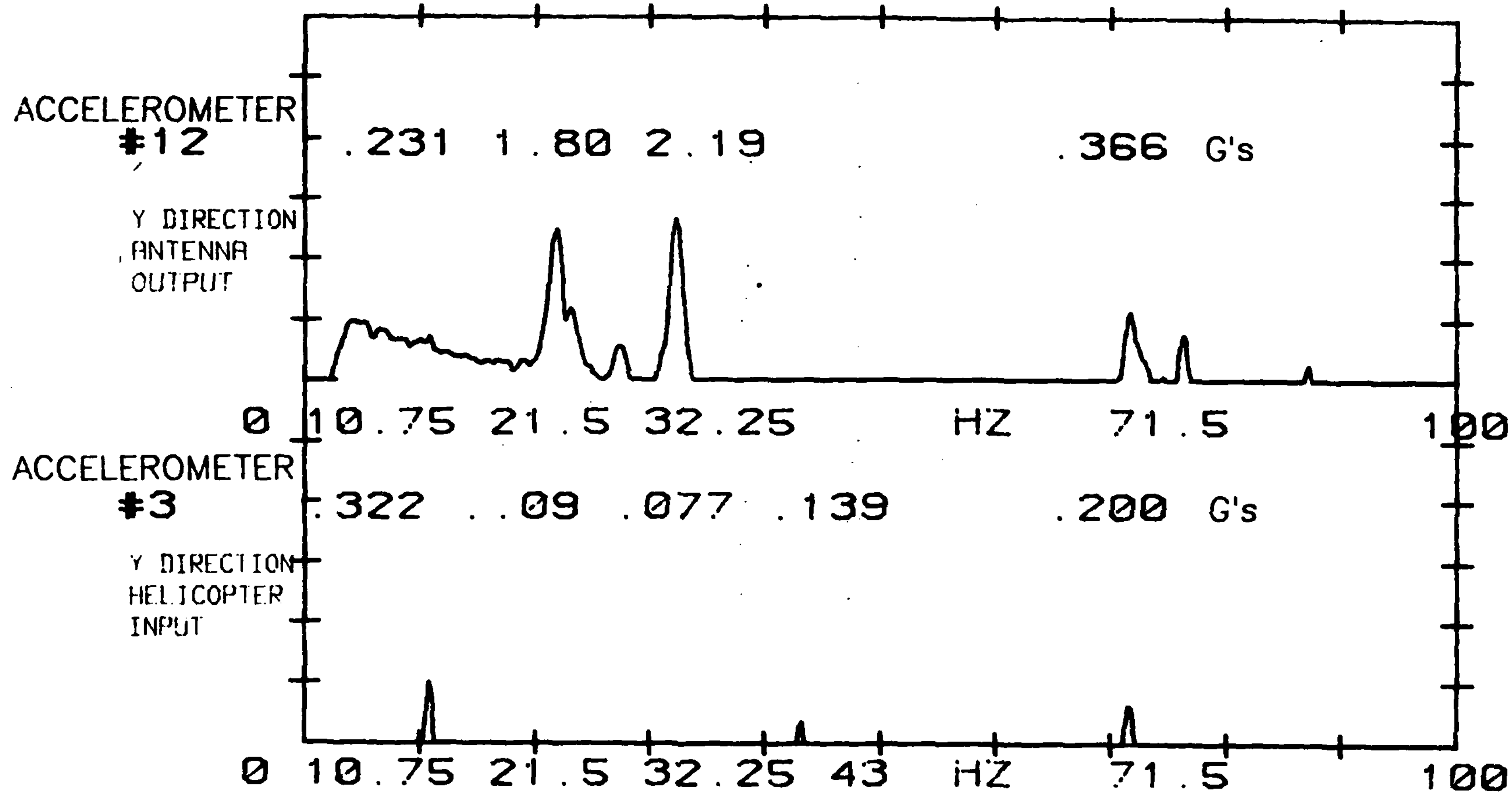


FIGURE 17. HOVER 1000 FEET: ACCELEROMETERS 3 AND 12

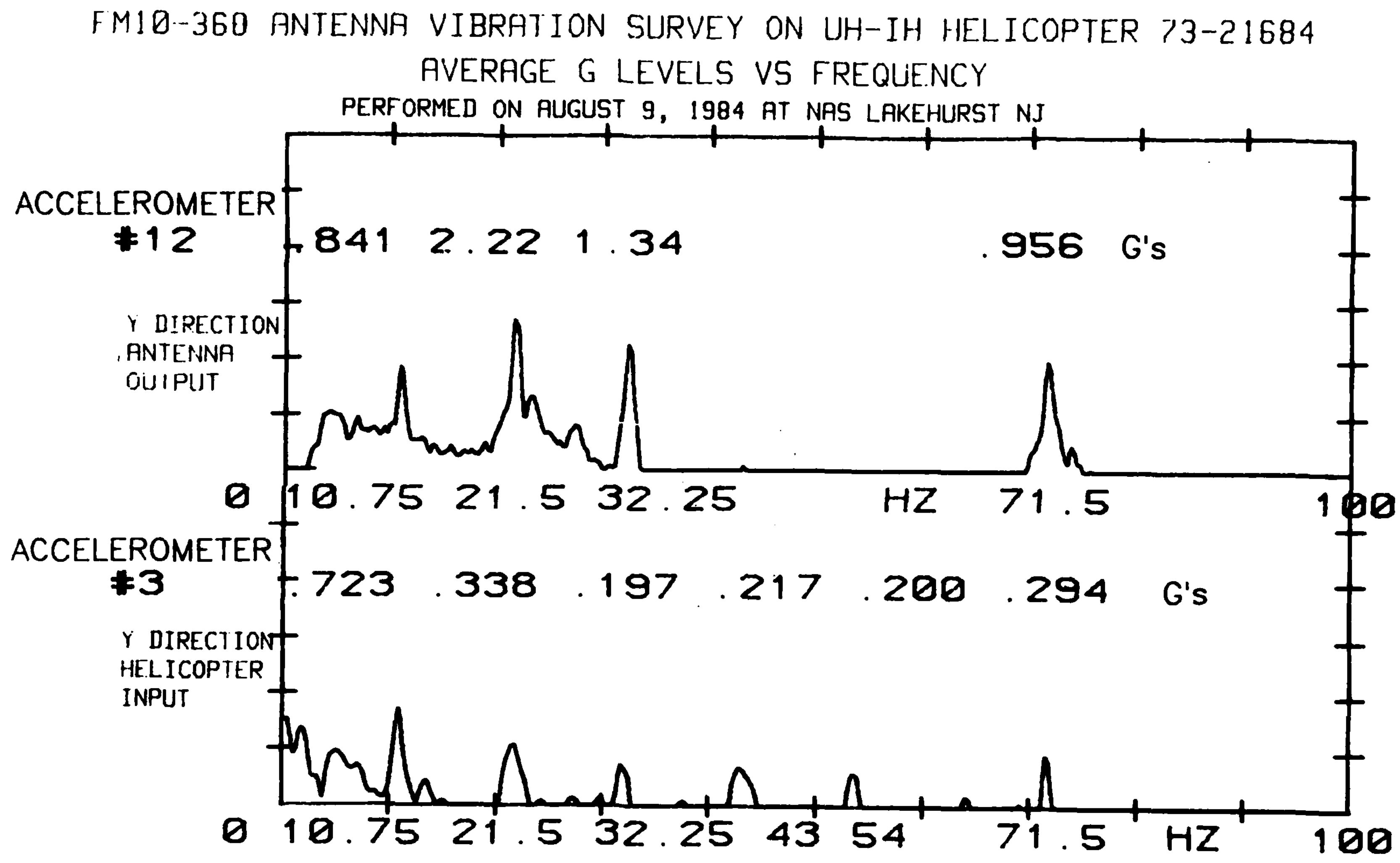


FIGURE 18. LOW LEVEL FLIGHT 70-75 KNOTS, UNDER 50 FT: ACCELEROMETERS 3 AND 12

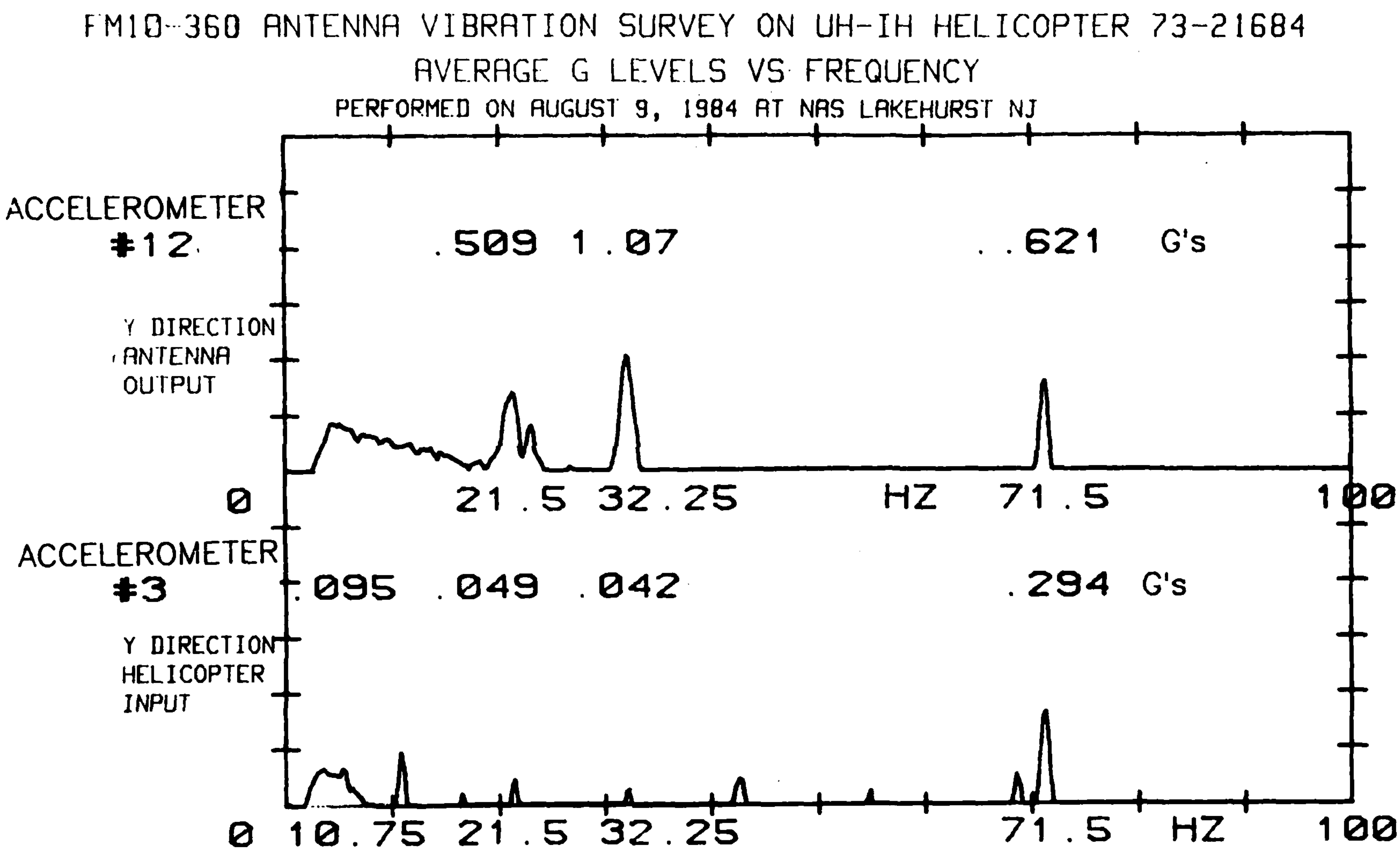


FIGURE 19. IN GROUND EFFECT (IGE) HOVER 10-15 FT: ACCELEROMETERS 3 AND 12

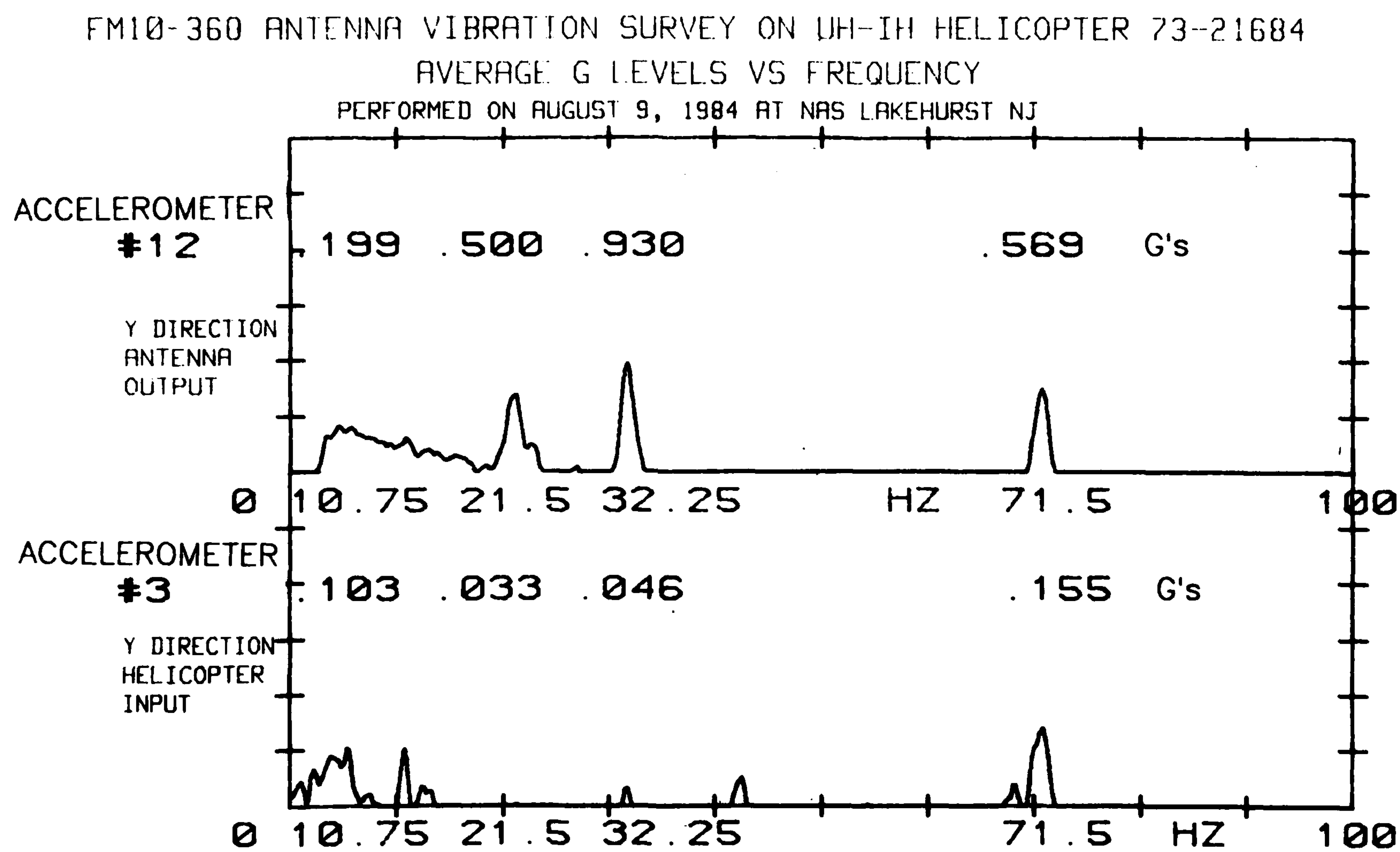


FIGURE 20. LANDING AND ENGINE SHUTDOWN: ACCELEROMETERS 3 AND 12

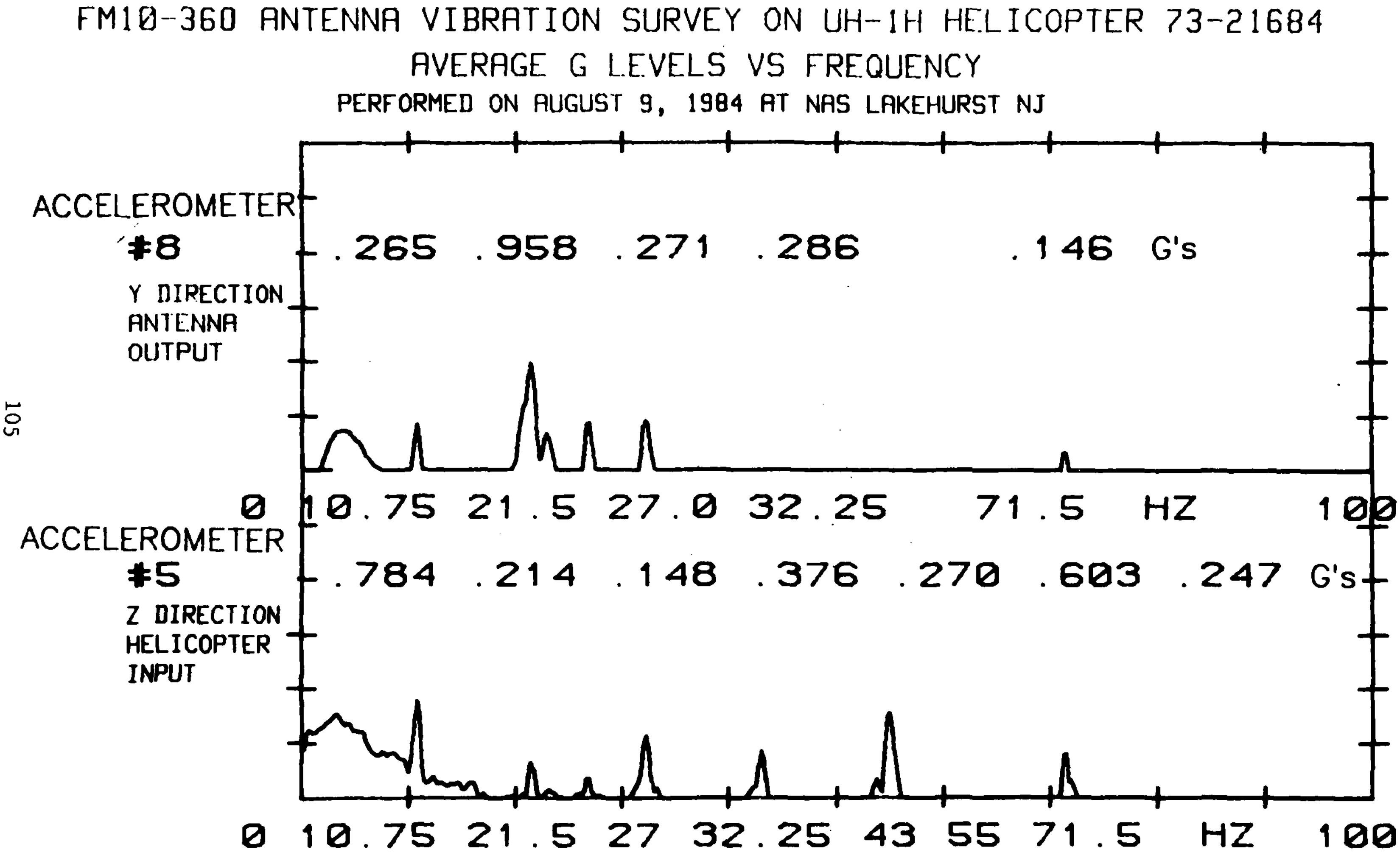
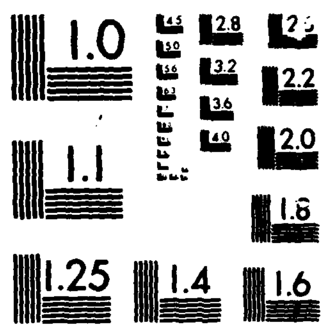


FIGURE 21. GROUND RUNUP 324 RPM: ACCELEROMETERS 5 AND 8

AD-A165 897 VHF-FM COMMUNICATIONS ANTENNAS FOR PROJECT SINCGARS 2/2
(UH-1 TAIL WHIP ANTENNA EVALUATION)(U) ARMY AVIATION
SYSTEMS COMMAND ST LOUIS MO J CARALYUS ET AL. FEB 86
UNCLASSIFIED AVSCOM-TR-85-E-2 F/G 17/2.1 NL



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FM10-360 ANTENNA VIBRATION SURVEY ON UH-1H HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

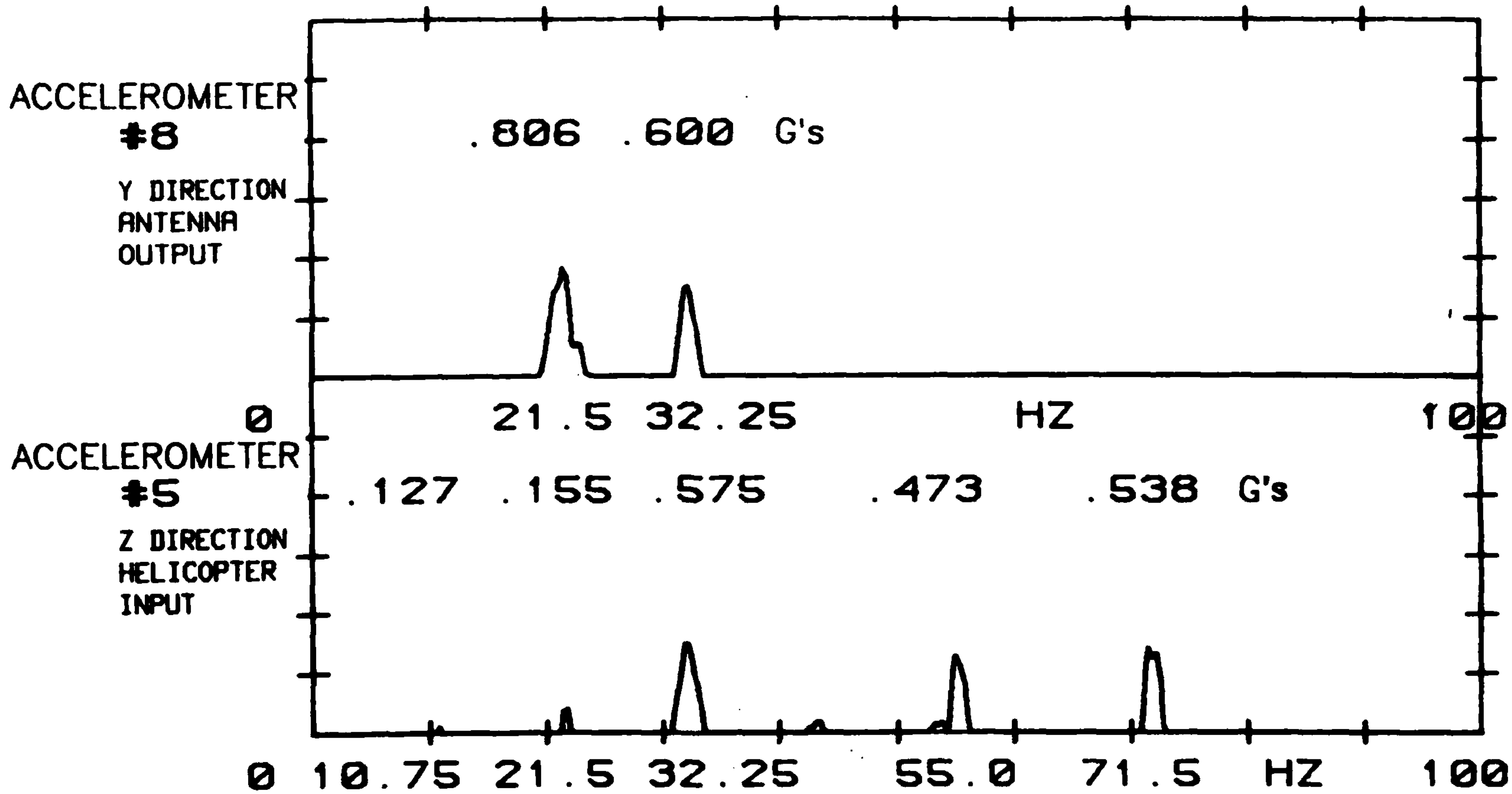

FIGURE 22. TAXI AND TAKEOFF: ACCELEROMETERS 5 AND 8

FM10-360 ANTENNA VIBRATION SURVEY ON UH-1H HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

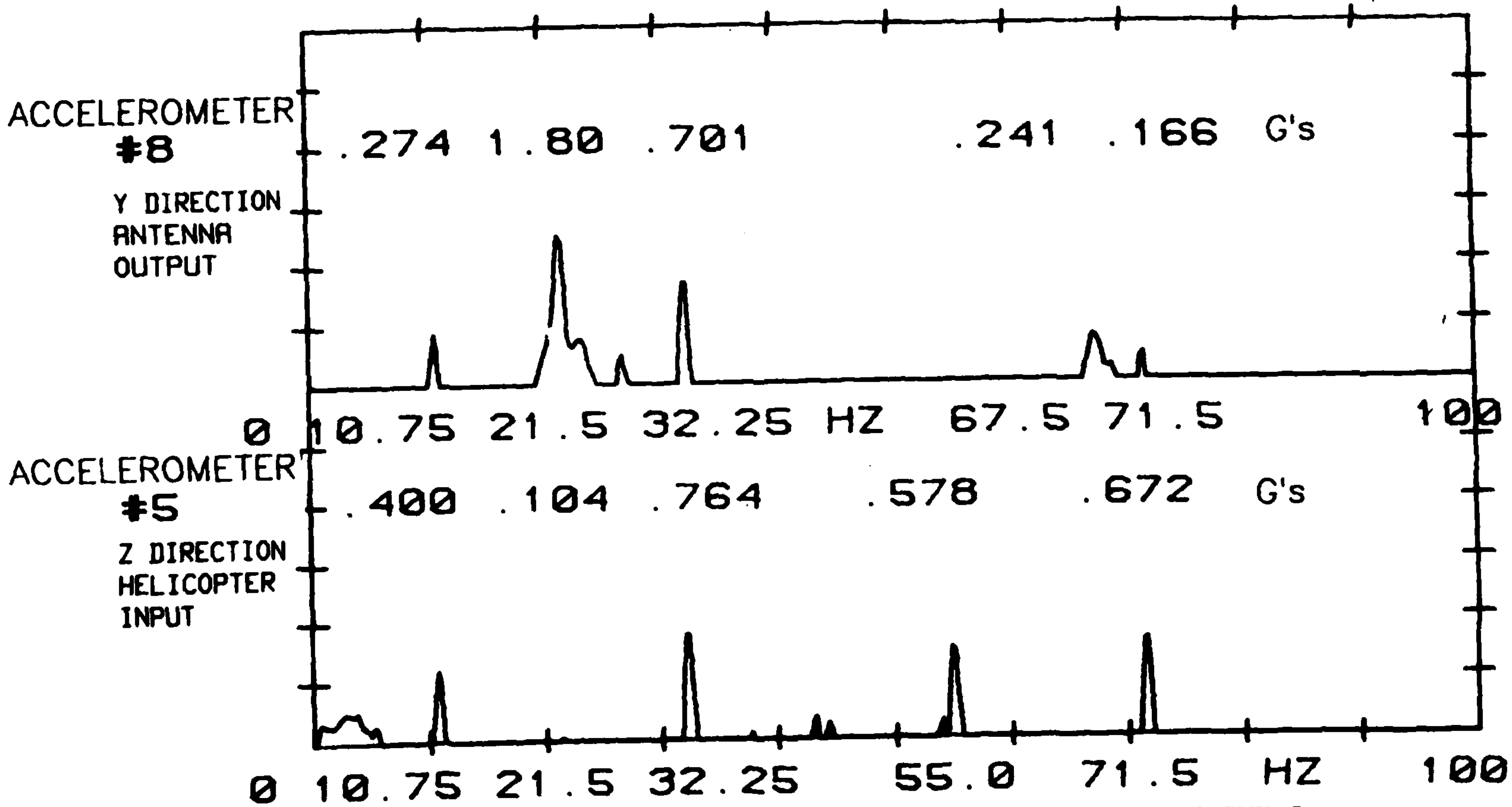

FIGURE 23. LEVEL FLIGHT 70-80 KNOTS, 100-3000 FT: ACCELEROMETERS 5 AND 8

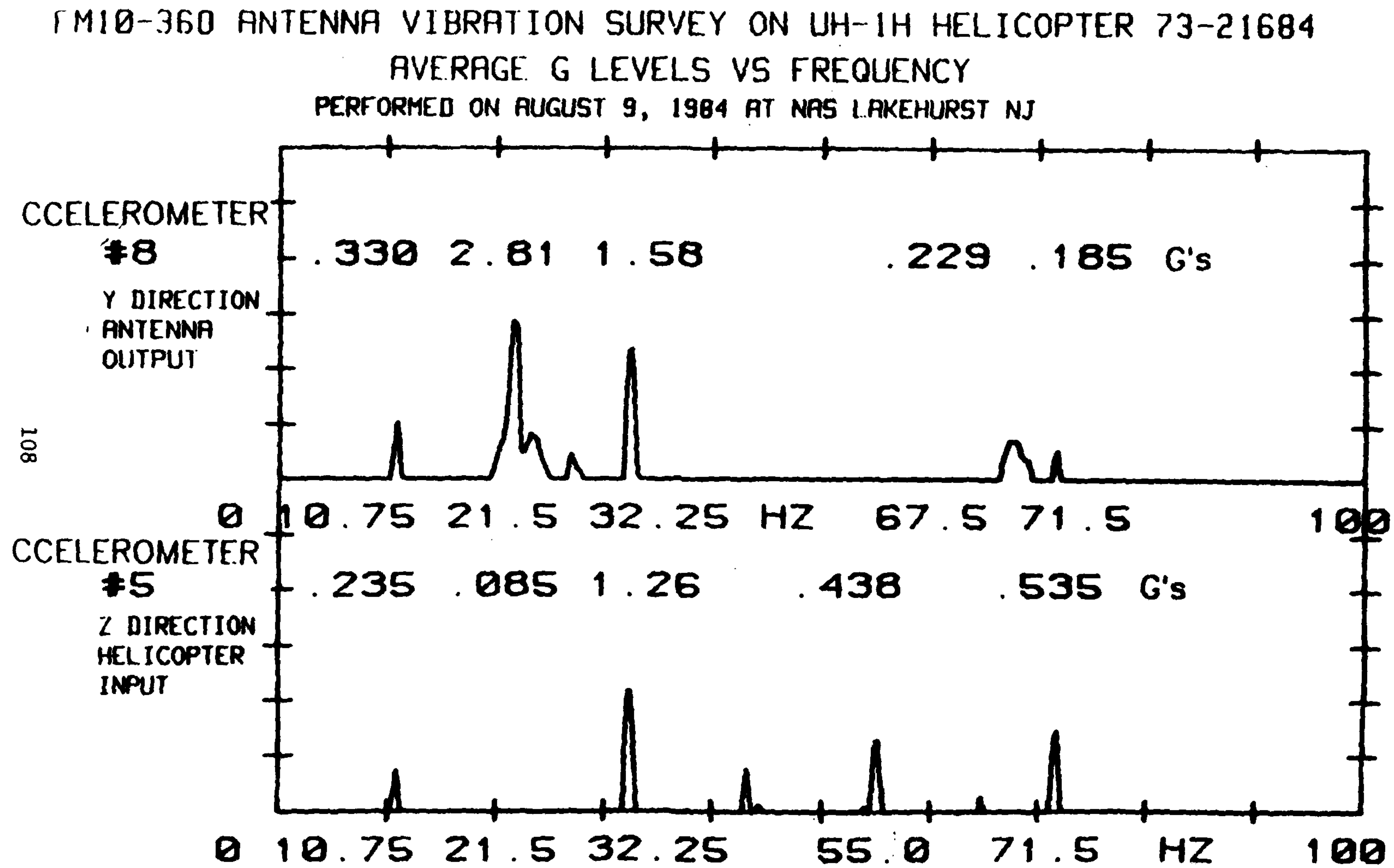

FIGURE 24. LEVEL FLIGHT 90-95 KNOTS, 3000 FT: ACCELEROMETERS 5 AND 8

FM10 360 ANTENNA VIBRATION SURVEY ON UH-1H HELICOPTER 73-21684
AVERAGE G LEVELS VS FREQUENCY
PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

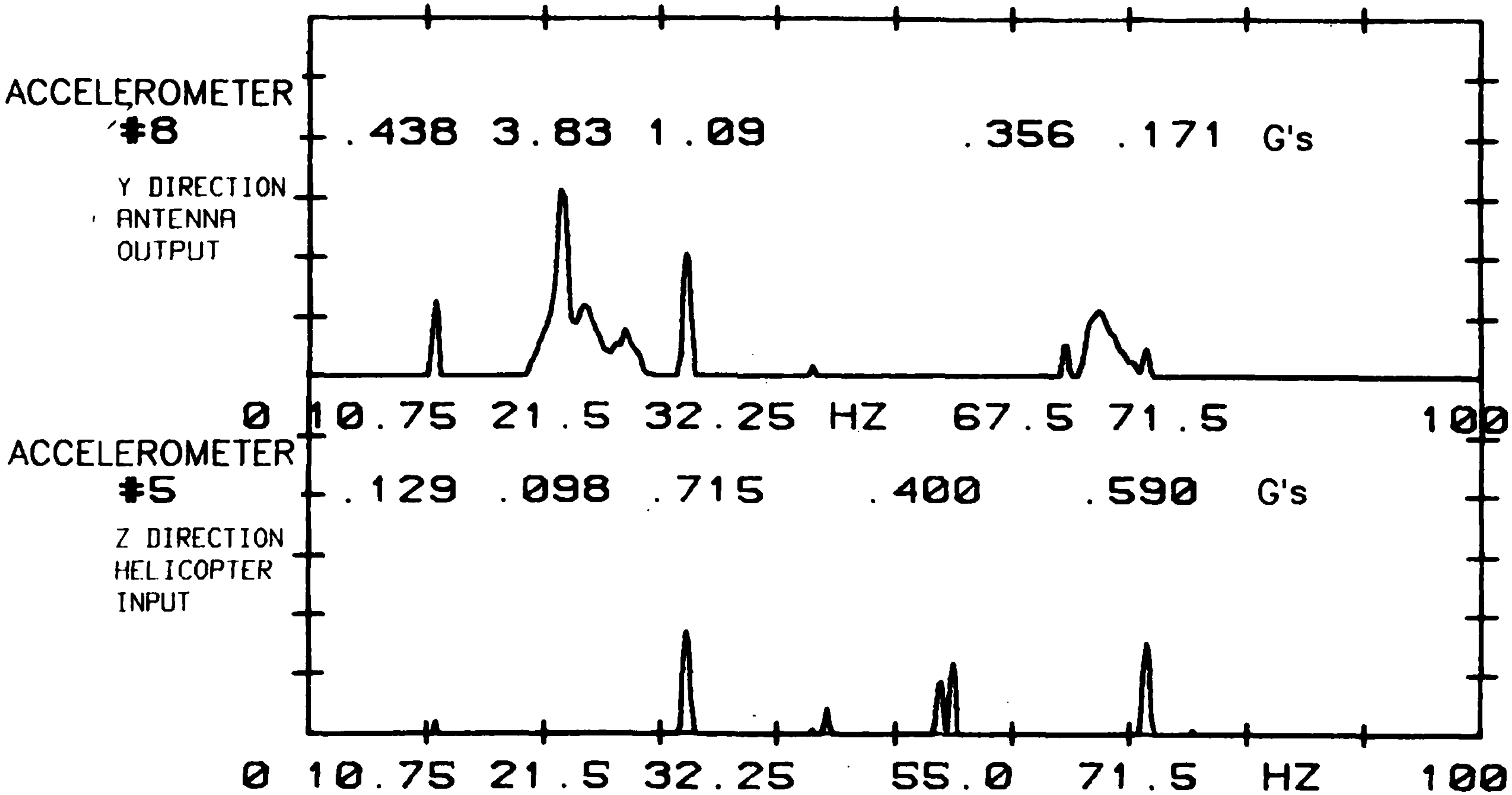

FIGURE 25. LEVEL FLIGHT 105-110 KNOTS, 3000 FT: ACCELEROMETERS 5 AND 8

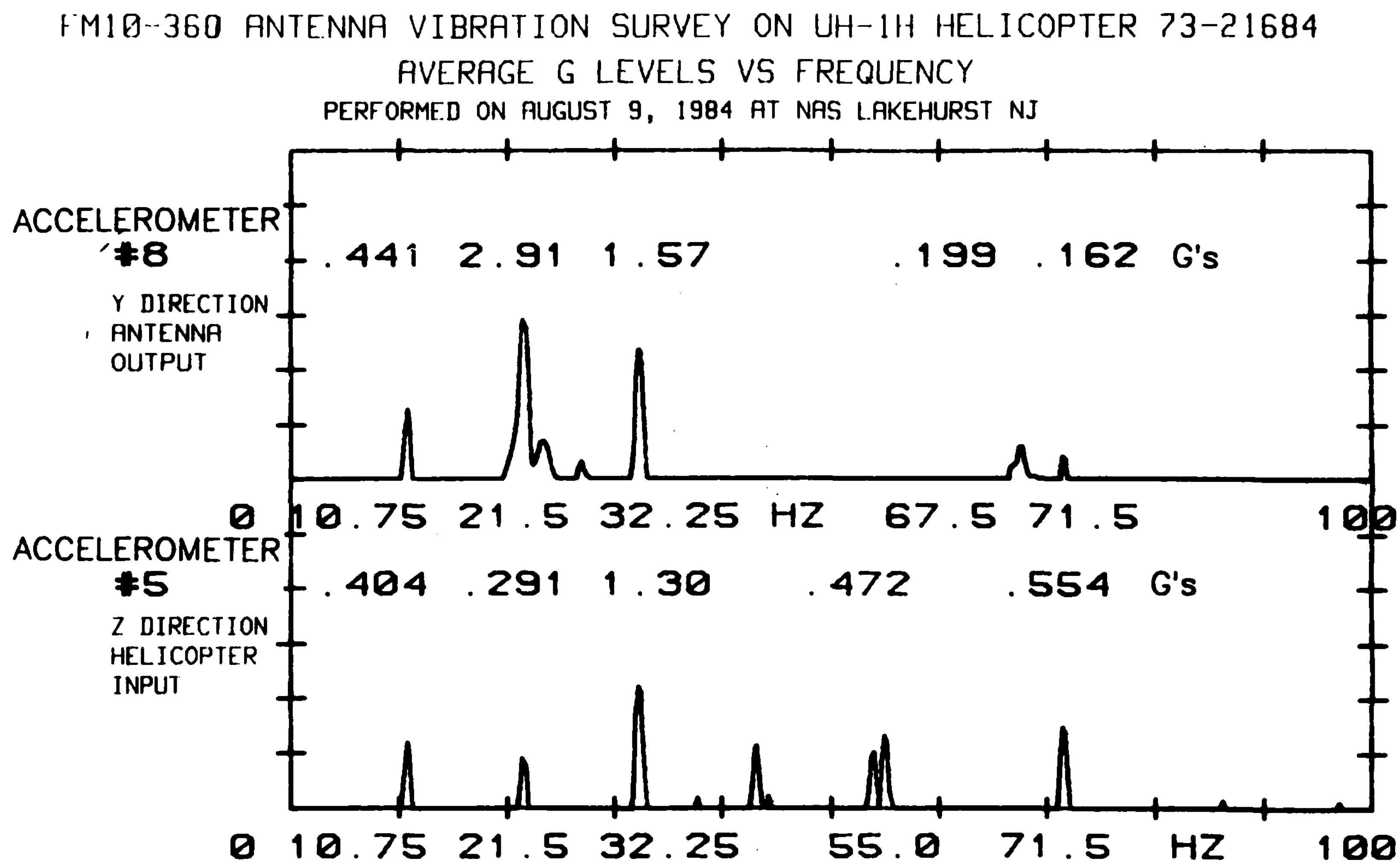

FIGURE 26. 45 LEFT BANK 70-75 KNOTS, 2800 FT: ACCELEROMETERS 5 AND 8

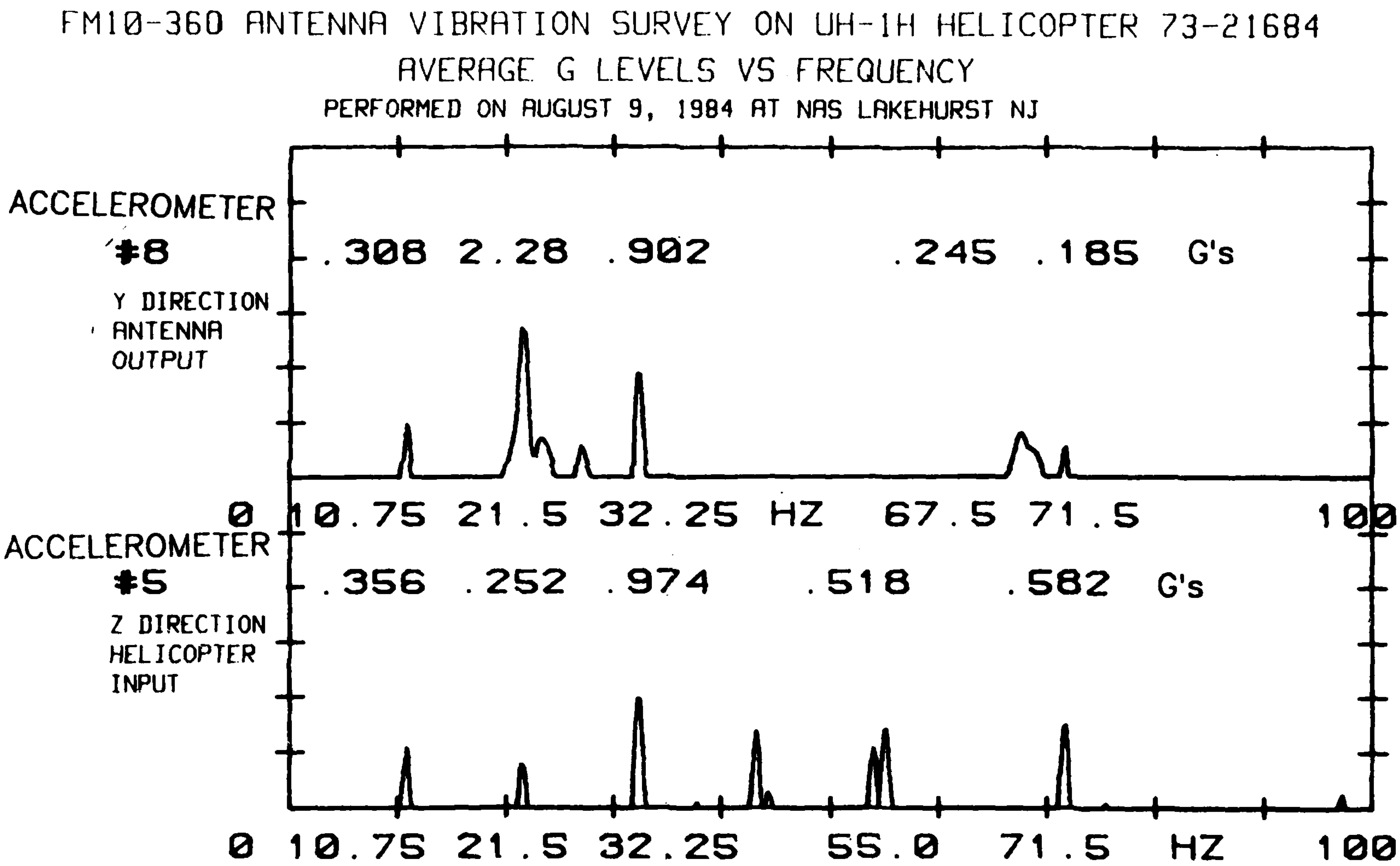

FIGURE 27, 45 RIGHT BANK 70-75 KNOTS, 2800 FT: ACCELEROMETERS 5 AND 8

FM10-360 ANTENNA VIBRATION SURVEY ON UH-1H HELICOPTER 73-21684
AVERAGE G LEVELS VS FREQUENCY
PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

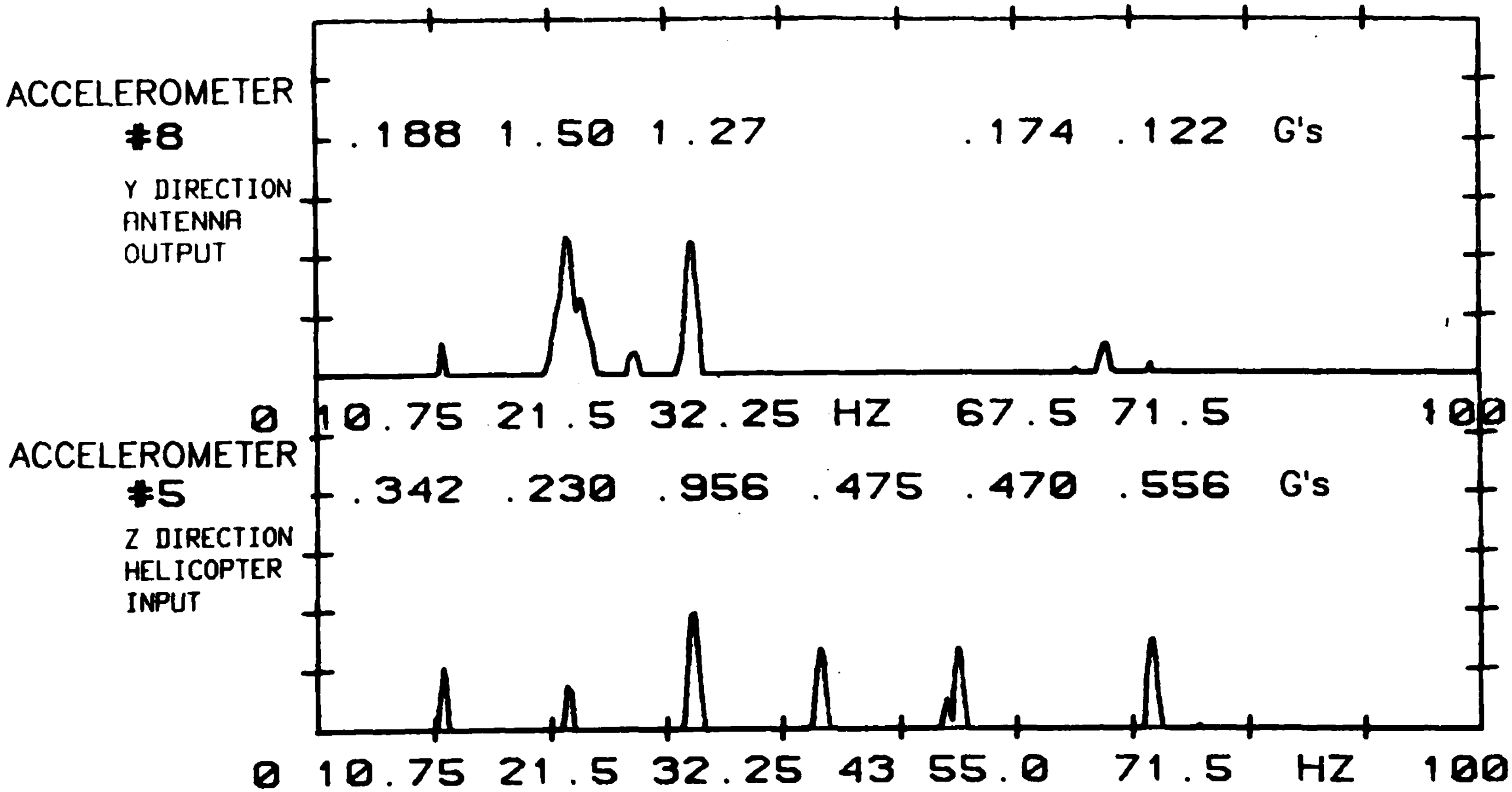

FIGURE 28. HOVER 1000 FEET: ACCELEROMETERS 5 AND 8

FM10-360 ANTENNA VIBRATION SURVEY ON UH-1H HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

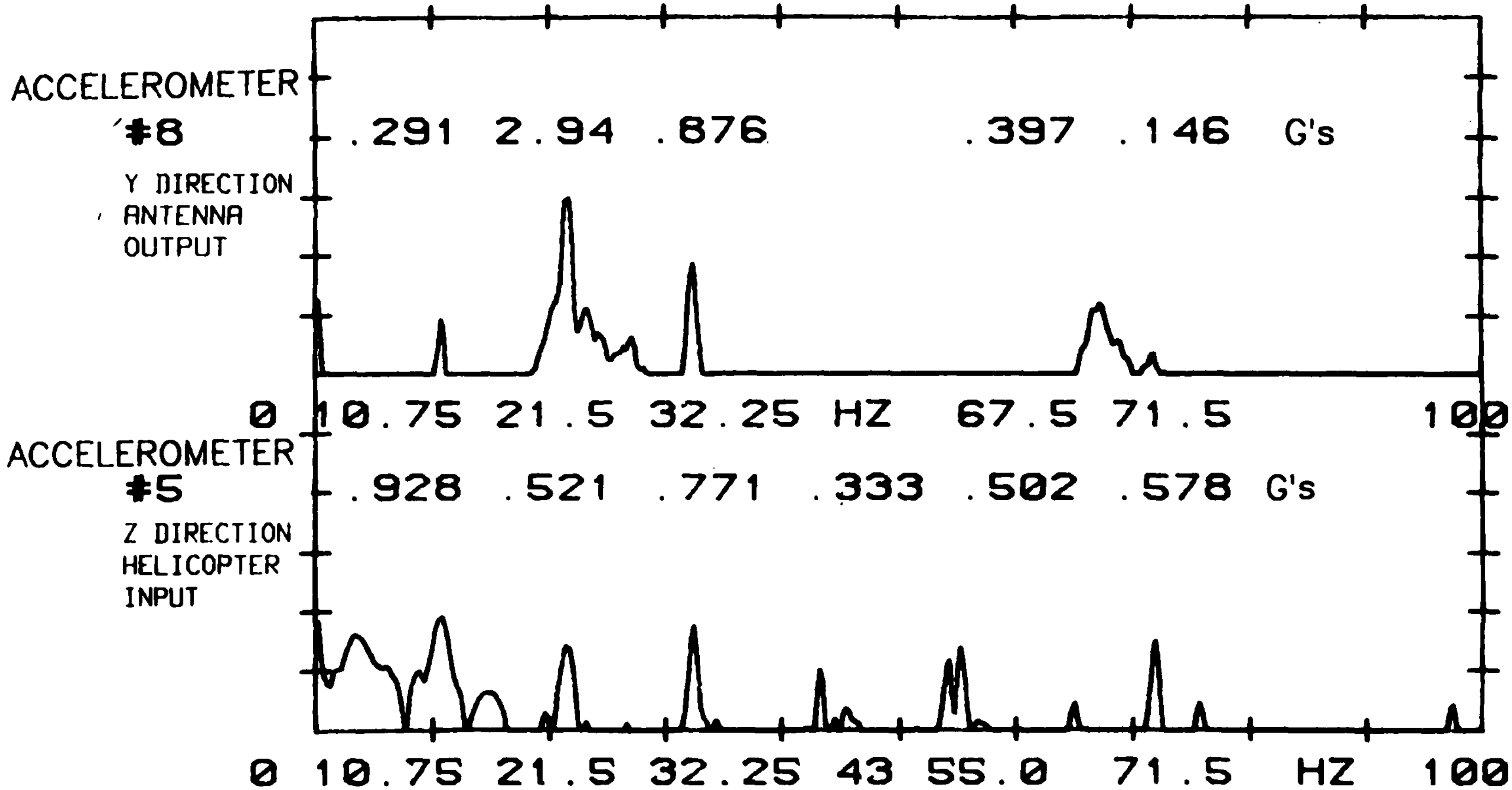

FIGURE 29. LOW LEVEL FLIGHT 70-75 KNOTS, UNDER 50 FT: ACCELEROMETERS 5 AND 8

FM10-360 ANTENNA VIBRATION SURVEY ON UH-1H HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

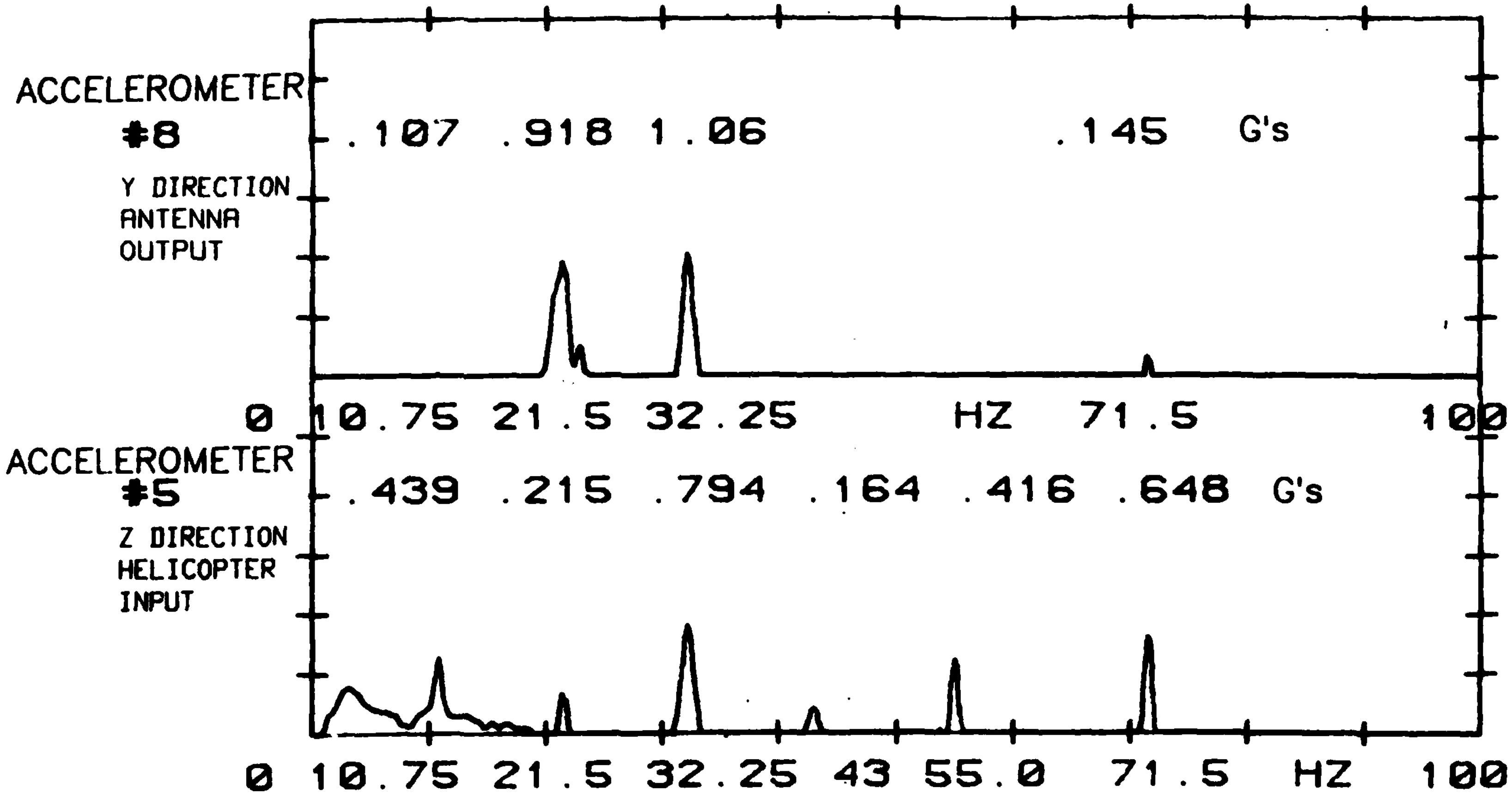

FIGURE 30. IN GROUND EFFECT (IGE) HOVER 10-15 FT: ACCELEROMETERS 5 AND 8

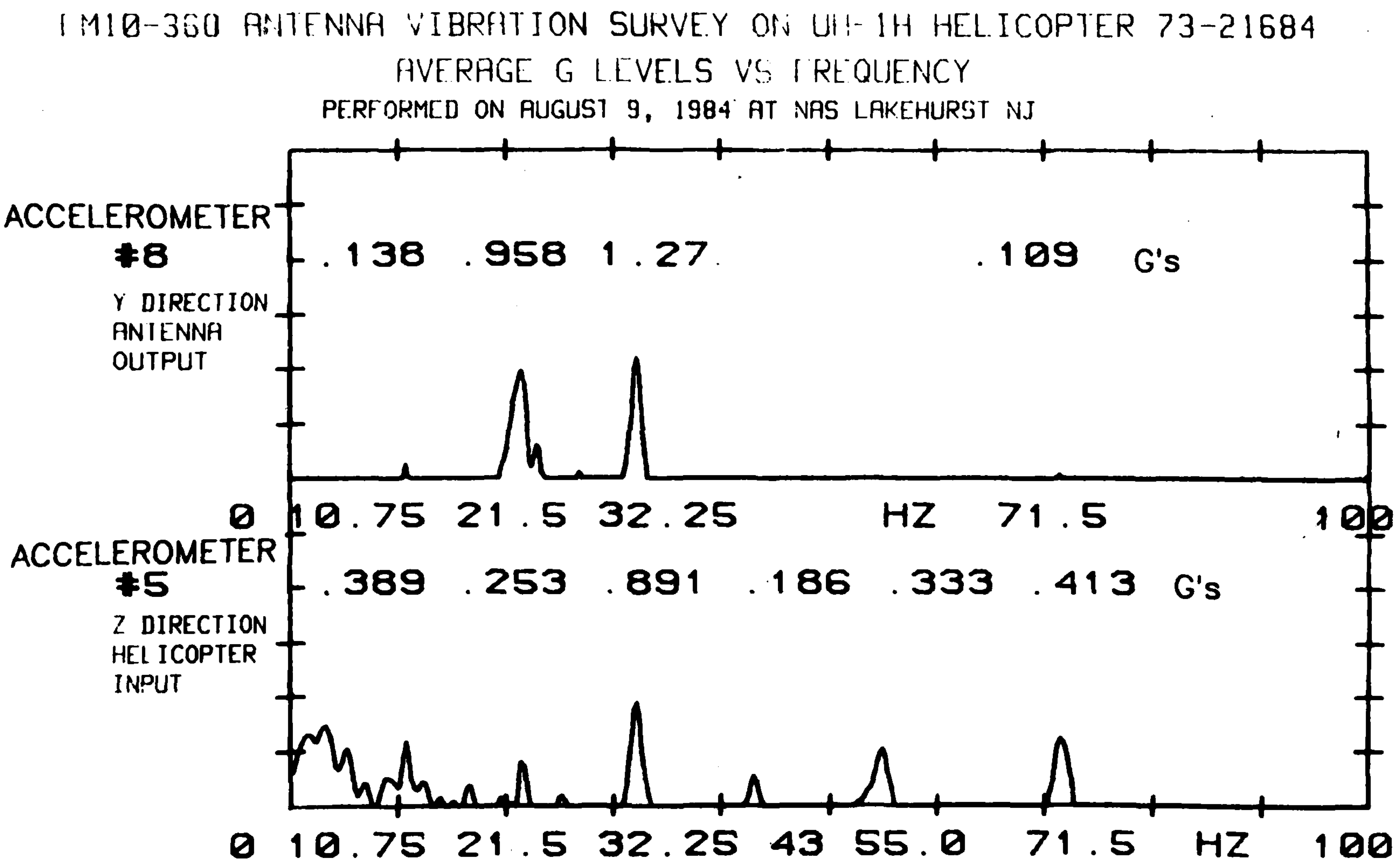

FIGURE 31. LANDING AND ENGINE SHUTDOWN: ACCELEROMETERS 5 AND 8

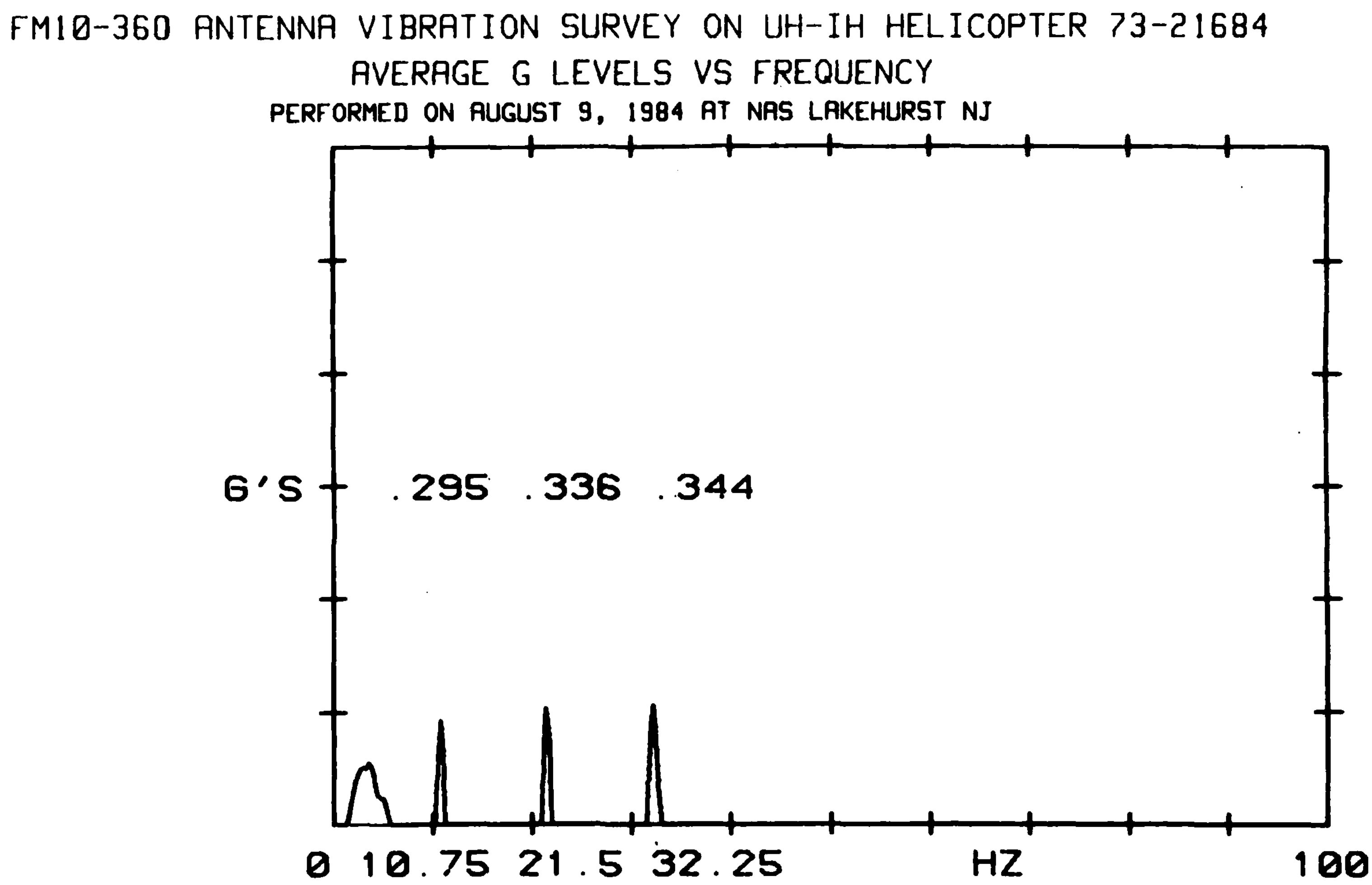

FIGURE 32. X DIR HELICOPTER INPUTS
CONDITION · GROUND RUNUP 324 RPMS

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684
AVERAGE G LEVELS VS FREQUENCY
PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

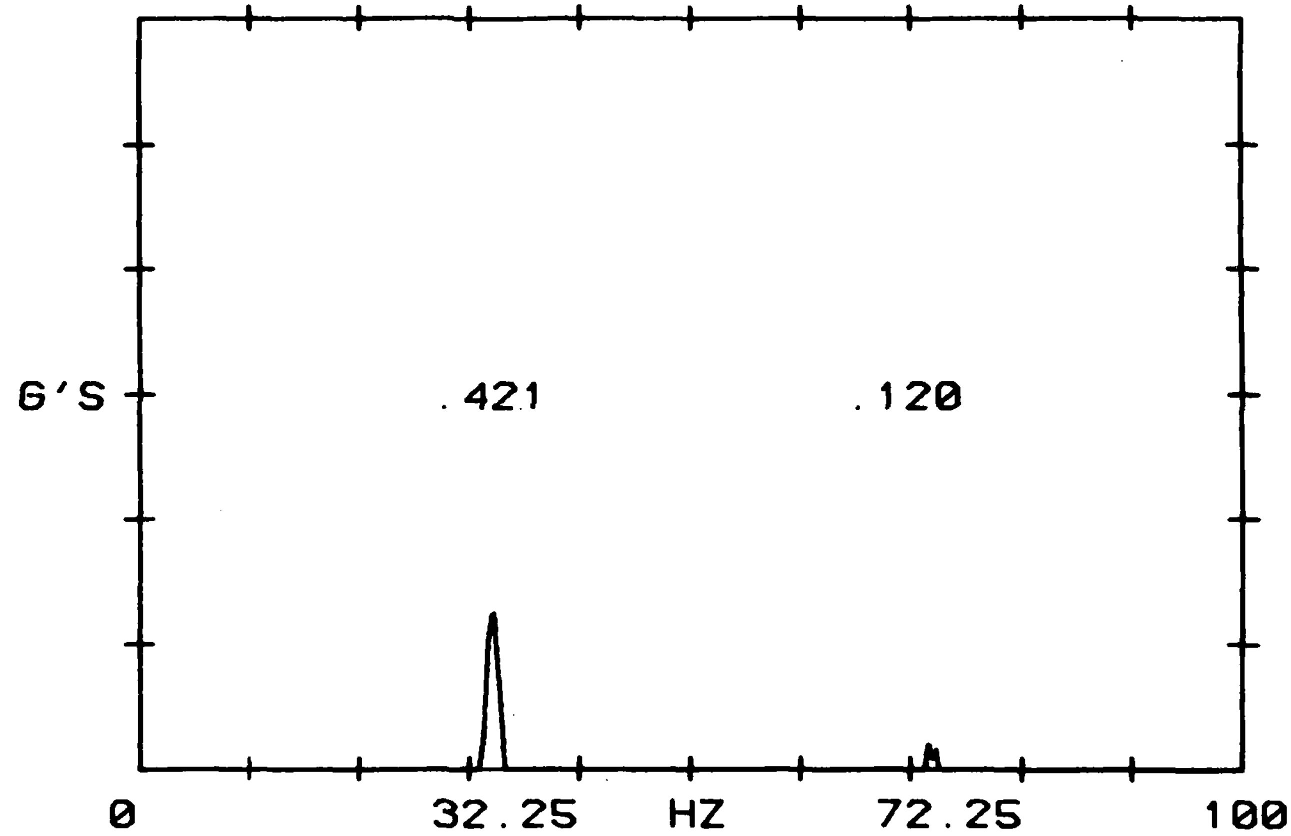

FIGURE 33. X DIR HELICOPTER INPUTS
CONDITION: TAKEOFF AND TAXI

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684
AVERAGE G LEVELS VS FREQUENCY
PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

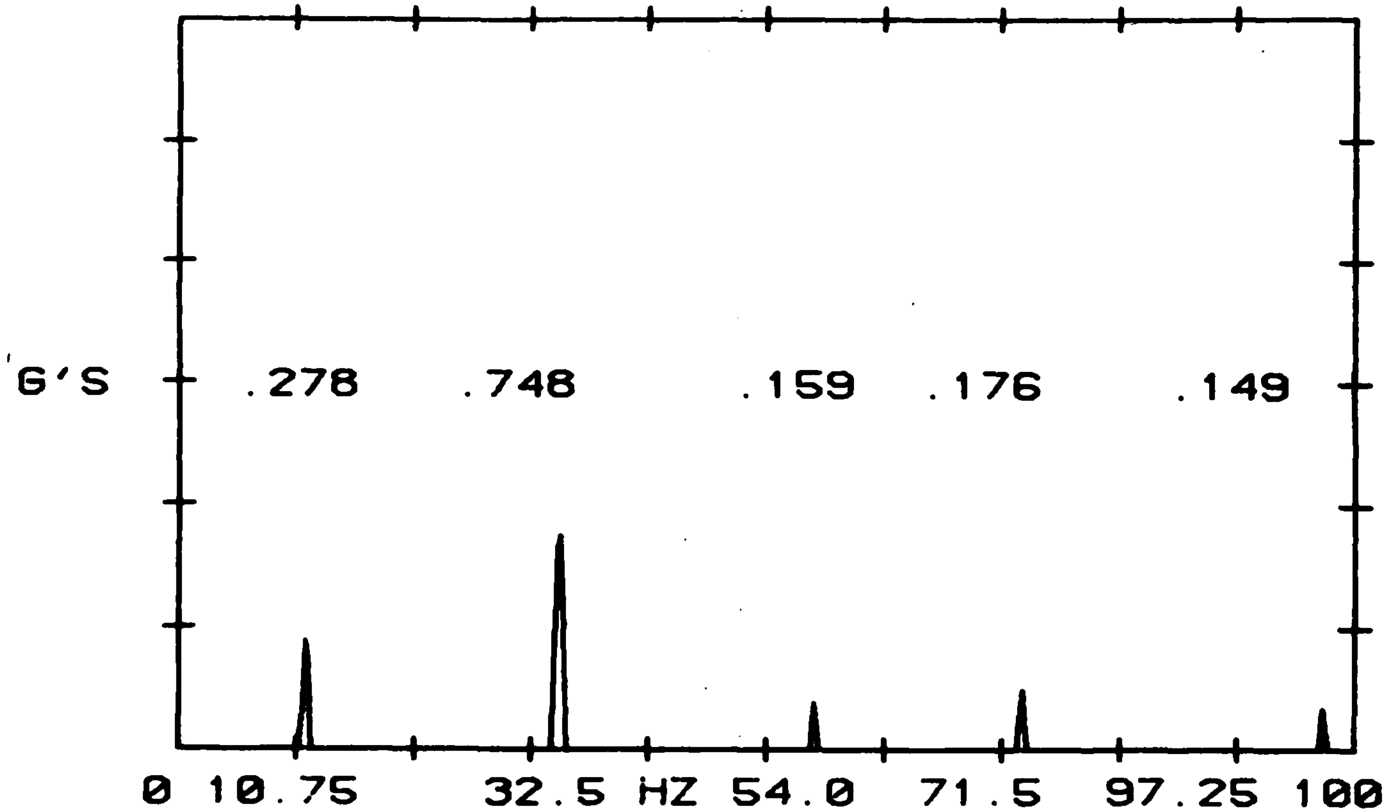

FIGURE 35. X DIR HELICOPTER INPUTS
CONDITION: LEVEL FLIGHT 110 KNOTS

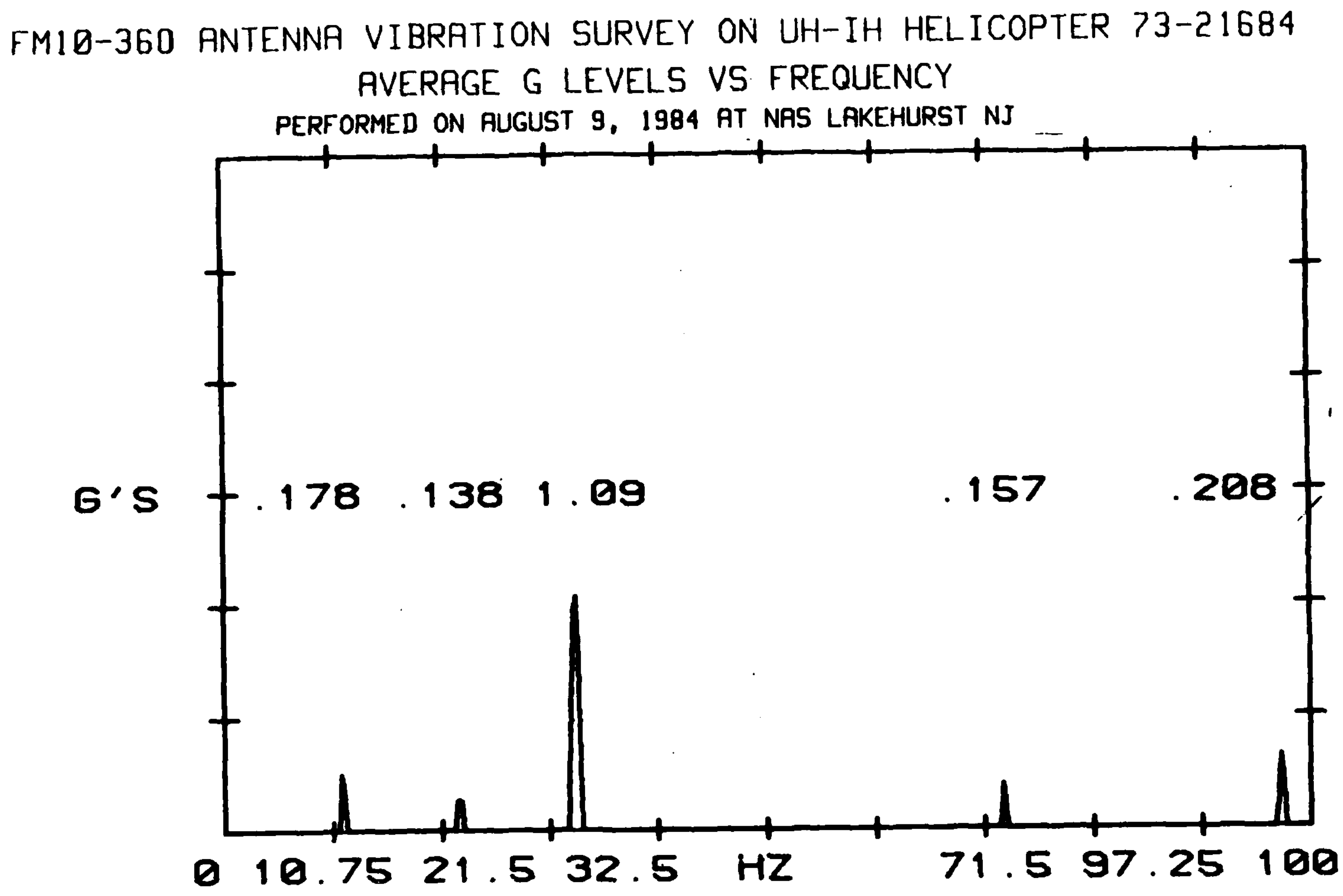

FIGURE 36. X DIR HELICOPTER INPUTS
CONDITION: 45 DEG LEFT BANK TURN

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684
AVERAGE G LEVELS VS FREQUENCY
PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

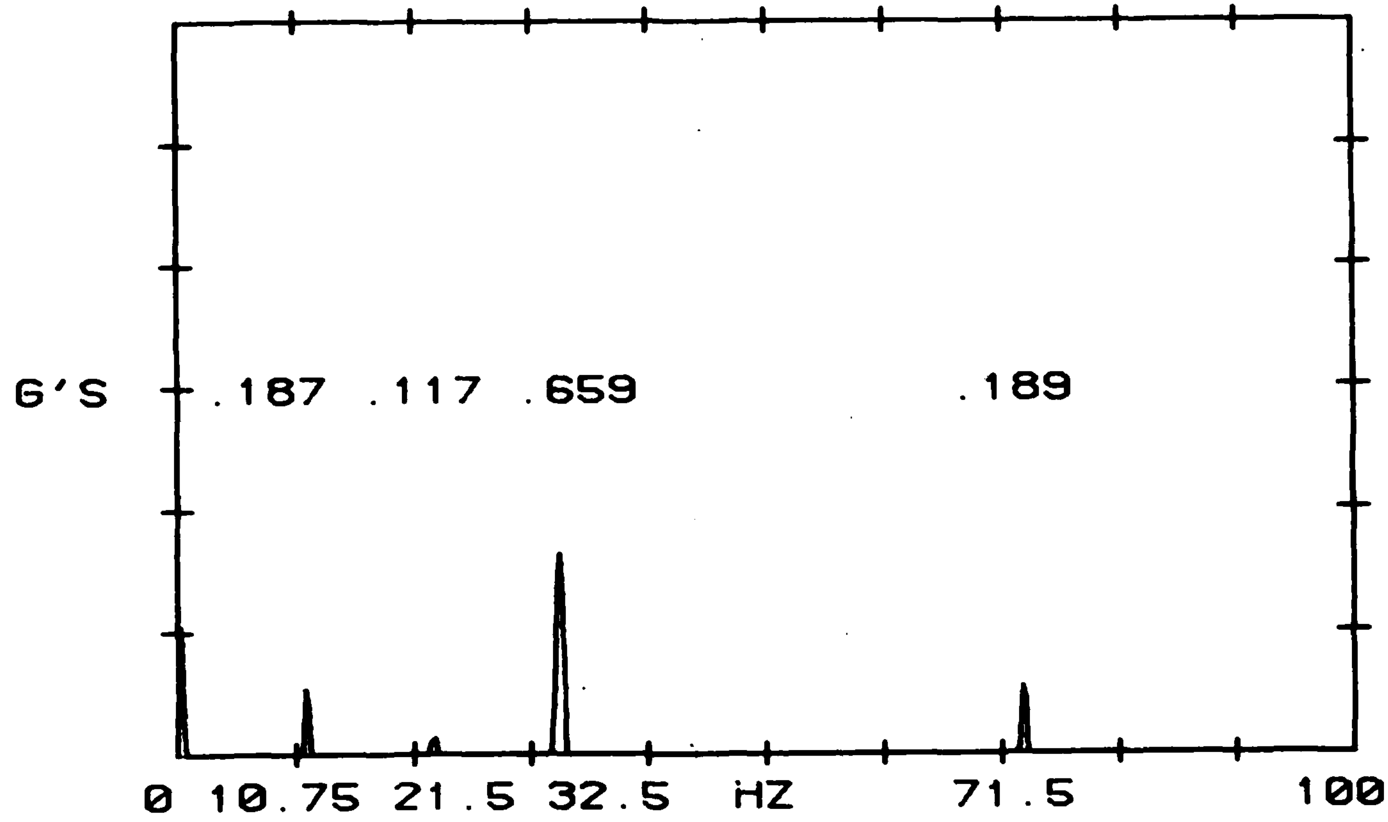

FIGURE 37. X DIR HELICOPTER INPUTS
CONDITION: 45 DEG RIGHT BANK TURN

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684
AVERAGE G LEVELS VS FREQUENCY
PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

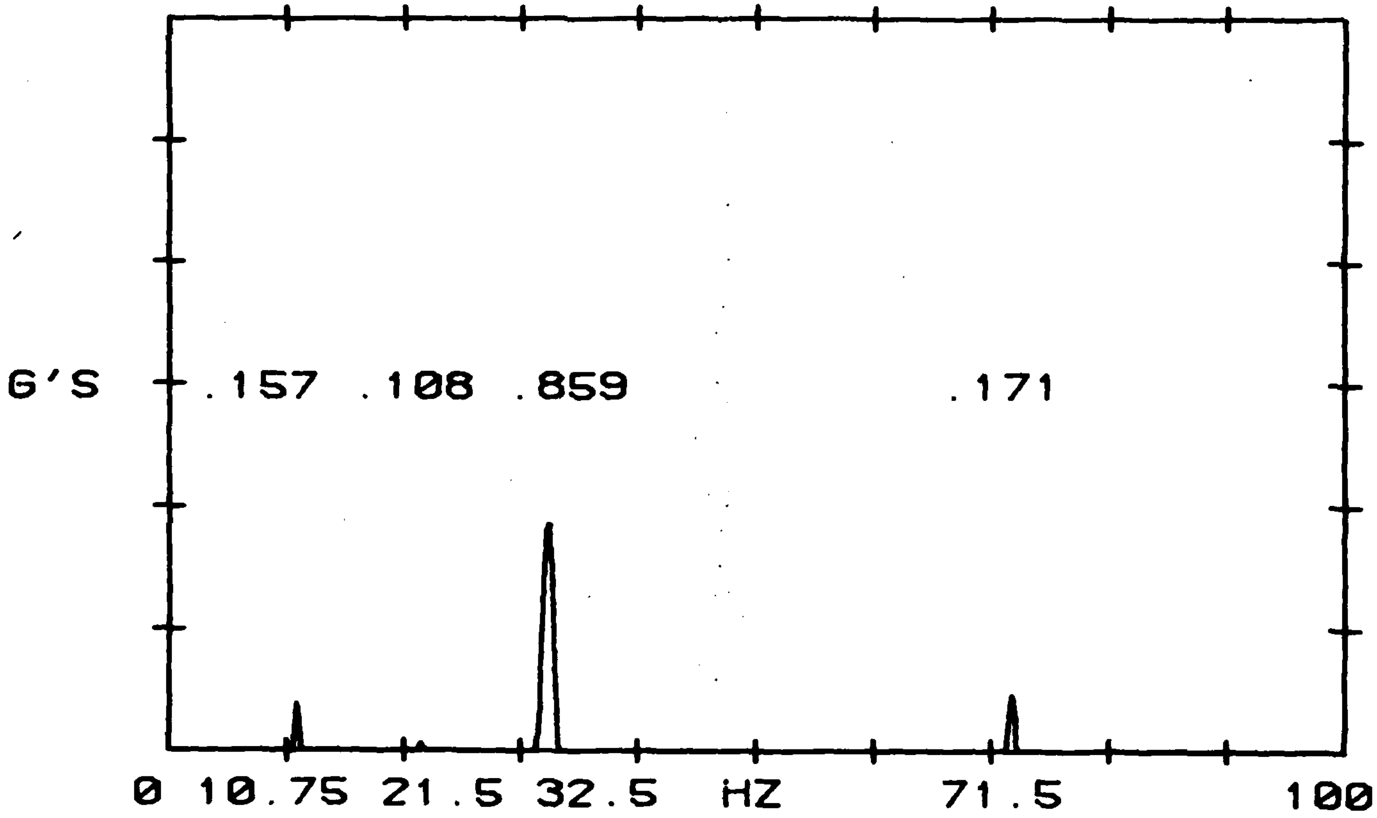

FIGURE 38. X DIR HELICOPTER INPUTS
CONDITION: HOVER AT 1000 FEET

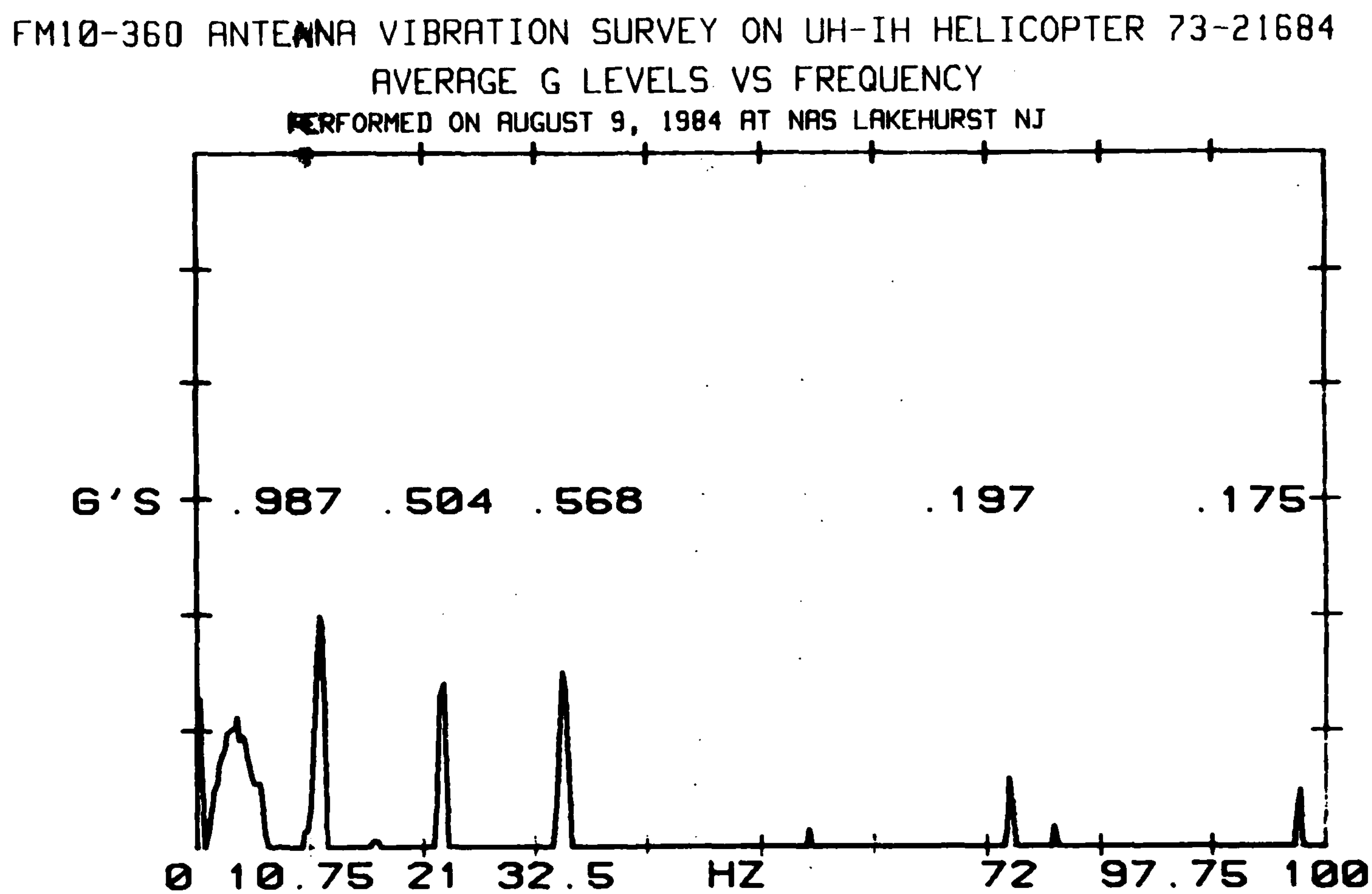

FIGURE [illegible]. X DIR HELICOPTER INPUTS
CONDITION: 30 FT ALT LEVEL FLIGHT

FM10-360 ANTENNA VIBRATION SURVEY ON UH-IH HELICOPTER 73-21684

AVERAGE G LEVELS VS FREQUENCY

PERFORMED ON AUGUST 9, 1984 AT NAS LAKEHURST NJ

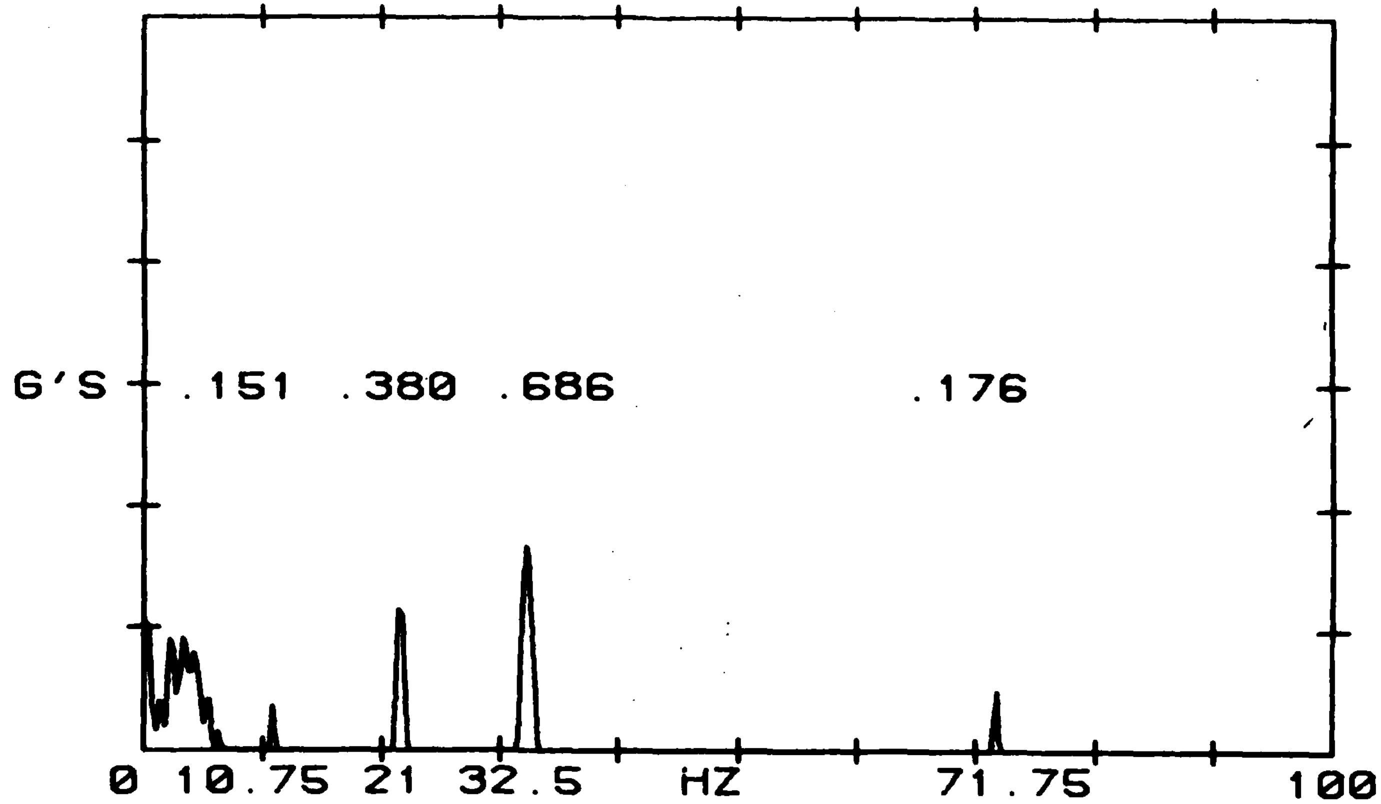

FIGURE 40. X DIR HELICOPTER INPUTS
CONDITION: GROUND EFFECT HOVER

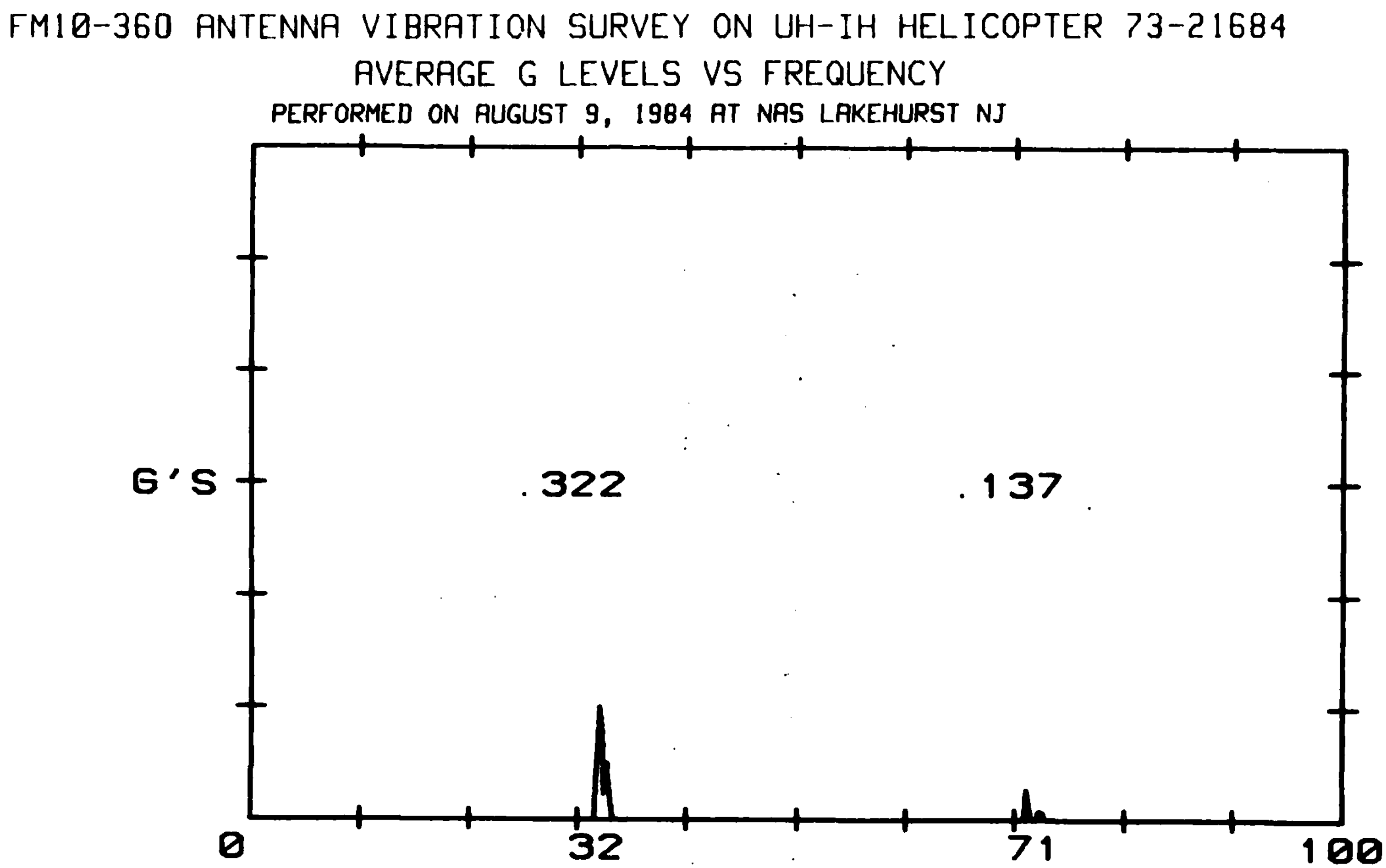

FIGURE 41. X DIR HELICOPTER INPUTS
CONDITION: LANDING

frequency Hz	helicopter input direction	level G's RMS	antenna output direction	level G's RMS	amplification factor= output/input
Ground Run-Up					
10.75	#3Y	2.49	#12Y	4.23	1.70
21.5	#3Y	1.58	#12Y	1.61	1.02
32.25	#3Y	2.02	#12Y	1.21	.60
43.00	#3Y	.852	#12Y	.798	.94
55.00	#5Z	.603	#12Y	.572	.95
65.00	#3Y	.558	#12Y	.471	.84
71.5	#5Z	.247	#12Y	.553	2.24
Taxi and Take Off					
10.75	#3Y	.419	#12Y	2.08	4.96
21.5	#3Y	.161	#12Y	.808	5.02
32.25	#5Z	.575	#12Y	1.12	1.95
43.0					
55.0	#5Z	.473			
65.0					
71.5	#5Z	.538	#12Y	.411	.76
Level Flight 70-80 Knots					
10.75	#3Y	.679	#12Y	1.43	2.10
21.5	#3Y	.211	#8Y	1.80	8.53
32.25	#5Z	.764	#12Y	1.21	1.58
43.0	#3Y	.125	#12Y	.277	2.22
55.0	#5Z	.578			
65.0					
71.5	#5Z	.672	#12Y	.506	.75

frequency Hz	helicopter input direction	level G's RMS	antenna output direction	level G's RMS	amplification factor= output/input
Level Flight 90-95 Knots					
10.75	#3Y	.541	#8Y	.330	.61
21.5	#5Z	.085	#8Y	2.81	33.06
32.25	#5Z	1.26	#12Y	2.41	1.90
43.00					
55.00	#5Z	.438			
71.5	#5Z	.535	#12Y	.632	1.18
Level Flight 105-110 Knots					
10.75	#3Y	.719	#8Y	.438	.61
21.5	#3Y	.129	#8Y	3.83	29.69
32.25	#5Z	.715	#12Y	1.42	1.99
43.0					
55.0	#5Z	.400			
65.0					
71.5	#5Z	.590	#12Y	.530	.90
45 Degree Banked Left Turn					
10.75	#3Y	.640	#8Y	.441	.69
21.5	#5Z	.291	#8Y	2.91	10.00
32.25	#5Z	1.30	#12Y	2.40	1.85
43.0	#3Y	.241			
55.0	#5Z	.472			
65.0					
71.5	#5Z	.554	#12Y	.613	1.11

FIGURE 42. COMPARISON OF HELICOPTER INPUT VS ANTENNA OUTPUT (SHEET 1 OF 2)

45 Degree Right Banked Turn

frequency Hz	helicopter input direction	level G's RMS	antenna output direction	level G's RMS	amplification factor= output/input
10.75	#3Y	.543	#12Y	.367	.68
21.5	#5Z	.252	#8Y	2.28	9.05
32.25	#5Z	.974	#12Y	1.41	1.45
43.0	#3Y	.283			
55.0	#5Z	.518			
65.0					
71.5	#5Z	.582	#12Y	.661	1.14

OGE Hover

frequency Hz	helicopter input direction	level G's RMS	antenna output direction	level G's RMS	amplification factor= output/input
10.75	#5Z	.342	#12Y	.231	.68
21.5	#5Z	.230	#12Y	1.80	7.83
32.25	#3Y	.956	#12Y	2.19	2.29
43.0	#5Z	.475			
55.0	#5Z	.470			
65.0					
71.5	#5Z	.556	#12Y	.366	.66

Low Level Flight

frequency Hz	helicopter input direction	level G's RMS	antenna output direction	level G's RMS	amplification factor= output/input
10.75	#6X	.787	#12Y	.841	.85
21.5	#5Z	.521	#8Y	2.91	5.64
32.25	#5Z	.771	#12Y	1.34	1.74
43.0	#5Z	.333			
55.0	#5Z	.502			
65.0					
71.5	#5Z	.578	#12Y	.956	1.65

IGE Hover

frequency Hz	helicopter input direction	level G's RMS	antenna output direction	level G's RMS	amplification factor= output/input
10.75	#5Z	.439	#8Y	.107	.24
21.5	#6X	.380	#8Y	.918	2.42
32.25	#5Z	.794	#12Y	1.07	1.35
43.0	#5Z	.164			
55.0	#5Z	.416			
65.0					
71.5	#5Z	.648	#12	.621	.96

Landing and Shutdown

frequency Hz	helicopter input direction	level G's RMS	antenna output direction	level G's RMS	amplification factor= output/input
10.75	#5Z	.389	#12Y	.199	.51
21.5	#5Z	.253	#8Y	.958	3.79
32.25	#5Z	.891	#8Y	1.27	1.43
43.0	#5Z	.186			
55.0	#5Z	.333			
65.0					
71.5	#5Z	.413	#12Y	.569	1.38

FIGURE 40. COMPARISON OF HELICOPTER INPUT VS ANTENNA OUTPUT (SHEET 2 OF 2)

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